| | |
|---|---|
| | As a bonus, you can also find here access to Sustainability School to enhance your knowledge on sustainability competitive edge. |
| | |
| | Expand your presence in Residential market |
| | |
| | |
| | |
| | Fine-tune your skills for the Residential market — join eLearnings today |

| |
|---|
| Grow your skills and your network in the Residential market with the help of Schneider Electric. You'll lear through these processes. Also you find the basics of eMobility Residential Application. |
| |
| Discover basic and enriched wiring devices functions in Residential |
| |
| Understanding overcurrent protection |
| |
| How to select a Circuit Breaker |
| |
| How to Protect Against Electrocution |
| |

| |
|---|
| How to select the Type of Residual Current Device according to the application |
| |
| Discover the Easy9 system |
| |
| Discover the Acti9 System: M1 |
| |
| Low Voltage solutions for Commercial and Industrial Buildings |
| |
| |
| |
| Skill up with Schneider Electric today. Enjoy your time! |
| |

Learn the essentials of Low Voltage design and Power Distribution. Improve your skills through in-depth vi
knowledge in Primary Distribution, Motor Control, Motor Protection and management, cost optimization,

Electrical Installation Design

Motor Starters with Contactors

Motor Protections

Operation and Maintenance Tool

Safety & Availability

Discover EasyPact TVS

Discover ComPacT NSX and ComPacT NSXm Offer

Industrial Automation market

| | |
|---|---|
| | solutions |
| | |
| | |
| | |
| | Find new business opportunities in Industrial Automation Market — skill up starting today |
| | |

Learn more about Schneider Electric products and solutions for Industrial Automation market. Develop th
introducing an overview on key ranges.  eLearnings will help to increase your technical capabilities allowin

Drives Basics

Control & Signaling

Basic HMIs

Relays

Power Supplies and Universal Enclosures

Altivar Soft Starter & Variable Speed Drives

Secure Power solutions for data centers, critical power infrastructure and small offices

Gain new knowledge about Secure Power solutions

Discover the innovative, reliable, and energy-efficient solutions for critical power infrastructure and mediu
— the fully integrated, end-to-end uninterruptible power supply solutions helping to maintain enterprise-

The Schneider Electric UPS Family

The Small Office and Home Office for Sales Associates

Edge Network

Digital Power solutions to increase energy efficiency

Digital Power solutions help you increase electrical system and assets reliability for your customers, avoid dov
characteristics, functions, and applications of key product ranges.

Basic Power Metering

Learn about PowerTag, how to promote it, and how it contributes to the different digital systems in each segr

Discover PowerTag Energy Sensors

EasyLogic PM2000

Gateways and Energy Servers

The EcoStruxure Panel Server Portfolio Overview provides the trainee with an overview of SE gateways an

EcoStruxure Panel Server

Power Quality and Power Factor Correction

Gain more knowledge in Power Quality and Power Factor Correction in short videos

Power Quality and LV Power Factor Correction

LV Power Factor Correction components

Selection of the right LV Capacitor

Protection Relays

This course provides an overview of offer values and ways to address customer pain points

Easergy P1

Sustainability School

Gain sustainability knowledge and skills

Chapter 1: Gain knowledge

Business and sustainability go hand in hand today. In fact, the survival of our planet depends on it. Sparke
Elevate your brand's reputation and stand apart from the competition. Start with Chapter 1 of Schneider E
gain a competitive edge. Chapters 2 and 3 are coming soon.

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Skip to main content

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Student

Navigation Menu

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Learner Home



Completions

0

Hours

Your Subjects

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Business Acumen, Cross-Functional, Customer Project Management, Customer Projects & Services, Digita
safety and Lockout Tagout, Electrical Engineering, Field Services Business Effectiveness, Field Services Mar
Automation and Control Software, Industrial Communication, Industry Specific, Information Technology, I
Employees, PLC, PAC and dedicated Controllers, Products, Solutions & Services, Safety, Safety Principles, S
Sustainable Development, Variable Speed Drives and Soft Starters, Water and Wastewater

Your Playlists

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Hi Tshingombe! What would you like to learn today?

Continue Learning

Curriculum

Schneider Home Certification

In Progress

Open Curriculum

Curriculum

In Progress

Curriculum

In Progress

Curriculum

In Progress

Curriculum

In Progress

Saved for Later

Curriculum

Sustainability School for Partners Chapter 2

In Progress

Launch

Most Popular

Online Class

The Thermal Management Functions in Electrical Panels: Module 02

30 minutes

Online Class

30 minutes

Online Class

30 minutes

Video

55 minutes

Test

30 minutes

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Open Curriculum

Curriculum

EBO 2023: Engineering EasyLogic

In Progress

Open Curriculum

Curriculum

EBO 2023: Engineering Upgrade

In Progress

Open Curriculum

Curriculum

EcoXpert Smart Grid, Technical, Intermediate: Geographic Information Systems Path

In Progress

Open Curriculum

Online Class

EcoStruxure Power Foundational 2.0

In Progress

Launch

Event

Advanced Machines with PacDrive 3 [VILT]

| | |
|---|---|
| | 20 hours |
| | |
| | |
| | |
| | |
| | |
| | Online Class |
| | |
| | EcoStruxure Building: Graphics Editor Intermediate |
| | |
| | |
| | |
| | In Progress |
| | |
| | |
| | |
| | |
| | |
| | Online Class |
| | |
| | Fundamentals of Thermal Management in Electrical Panels: Module 01 |
| | |
| | |
| | |
| | 30 minutes |

Video

SP_MX_2021_Lanzamiento Square D Easy UPS 3S 10-40 kVA (208V)

55 minutes

Test

IT Solution Provider Certification Test - Select

30 minutes

Sustai

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Main content below

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Transcript

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My Courses: Tshingombe fiston

My Courses: Tshingombe fiston

Use the transcript to manage all active training.

0 HRS

AGGREGATE TRAINING COMPLETED

FISCAL YEAR ENDING

12/31/2025

COST

R0.00

Filter by Training Status

Active

Sort by

Date Added

Filter by Training Type

All Types

Search by Keyword

Search

Search Results (134)

Schneider Home Certification

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

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EcoXpert Smart Grid, Technical, Intermediate: Geographic Information Systems Path

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

Basic Machines with PacDrive 3 [VILT] (Test)

Due : No Due Date Status : Failed Training Type : Test Training Status : Active

Cybersecurity für Schneider Electric Service Partner / Cybersecurity for Schneider Electric Services Partner

Due : No Due Date Status : In Progress Training Type : Online Class Training Status : Active

EBO 2023: Engineering EasyLogic

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

Service for Lexium [VILT] (Test)

Due : No Due Date Status : Failed Training Type : Test Training Status : Active

20 Mobile Terms You Probably Know

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EBO 2022: Engineering EBO

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EBO 2023: Engineering EBO

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EBO 2024: Engineering EBO

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EBO 2022: Value Based Selling

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

DIN Ethernet Technical Overview

Due : No Due Date Status : In Progress Training Type : Online Class Training Status : Active

| |
|---|
| Applying OWASP 2017 Mitigations<br>Series |
| |
| Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active |
| |
| |
| |
| EcoStruxure Power Foundational 2.0 |
| |
| Due : No Due Date Status : In Progress Training Type : Online Class Training Status : Active |
| |
| |
| |
| Fundamentals of Threat Modeling |
| |

Due : No Due Date Status : In Progress Training Type : Online Class Training Status : Active

Sustainability School for Partners Chapter 2

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

Basic Machines with PacDrive 3 (Test)

Due : No Due Date Status : Failed Training Type : Test Training Status : Active

EcoStruxure Building Technical Training For EcoXperts 2023 - Proficient

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

Introduction to EcoCare : Next Generation Services Membership

Due : No Due Date Status : Registered Training Type : Online Class Training Status : Active

Escola de Sustentabilidade para Parceiros. Capítulo 1/Sustainability School for Partners. Chapter 1 (Portugues

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

Motion Block : Part I (Test)

Due : No Due Date Status : Failed Training Type : Test Training Status : Active

Transformers and motor applications in industries

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EBO 2023: Engineering Upgrade

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

PowerLogic P5: Protection Engineering

Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active

EVlink ProAC Calibration Law Compliant Basic (German)

Due : No Due Date Status : Registered Training Type : Online Class Training Status : Active

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Content Training Installed Base Programs

Overview All Projects Project details

Project-28 Untitled

open

Created: 9/3/2025 Last Modified: 17/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingom

BOM Manager Activity Log Documents

Add products to Bill of Materials

By product reference number #

By Excel/CSV file ( Download sample template )

Error adding products View BOM

By product segments / selection tools

Programmable controllers and I/Os

PLC, PAC, IOs and Power supplies

Motor Protection & Control

VSD, Soft Starter, Direct Starter and protections

Human-machine interfaces

HMI panels, controllers, software and Industrial PCs

Interface, Safety and Control Relays

| |
|---|
| Electromechanical, Control, Timing and Solid State Relays |
| |
| Enclosures and Accessories |
| |
| Enclosures, thermal management, accessories and cabling |
| |
| Push Buttons, Switches, Pilot Lights and Joysticks |
| |
| Harmony ranges |
| |
| Motion Control and Robotics |
| |
| Move the machine tooling or the part itself in a controlled, rotary or linear manner. |
| |
| Power Control and Protection |
| |
| Power supplies and transformers |
| |
| Software License Configurator |
| |
| Software License Configurator |
| |

Bill of Materials

Total items selected: 1 Total: R 30 687,22

1

Controller, Modicon M171/M172/M173, optimized display 22 IO, Modbus

R 9 888,63

View Product

2

Modicon M171 Optimized LV Connector 1m cable

R 555,78

View Product

3

Modicon M171 Optimized AO Connector 1m cable

| |
|---|
| R 140,86 |
| View Product |
| 4 |
| Modicon M171 Optimized AO Connector 2m cable |
| R 201,24 |
| View Product |
| 5 |
| Modicon M171 Optimized Display LED |
| R 1 802,40 |
| View Product |
| 6 |
| Modicon M171 Optimized Display LCD |
| End of commercialisation: 12/01/2024 |

| |
|---|
| R 3 104,58 |
| |
| View Product |
| |
| 7 |
| |
| Modicon M171 Optimized Wall thermostat without backlight |
| |
| R 2 170,34 |
| |
| View Product |
| |
| 8 |
| |
| NTC 1,5m IP68 5x20 -50+110°C Grey |
| |
| R 143,76 |
| |
| View Product |
| |
| 9 |
| |
| NTC 1,5m IP68 5x20 -50+110°C Grey |
| |
| R 136,69 |
| |
| View Product |

| |
|---|
| 10 |
| NTC 3,0m IP68 5x20 -50+110°C Grey |
| End of commercialisation: 12/01/2024 |
| R 229,99 |
| View Product |
| 11 |
| EEV Driver, Actuator |
| End of commercialisation: 01/23/2021 |
| R 3 449,54 |
| View Product |
| 12 |
| EEV Driver, Autonomous & Hardwired |
| End of commercialisation: 01/23/2021 |
| R 3 737,01 |

View Product

13

EEV Driver, Autonomous & Modbus

End of commercialisation: 12/01/2024

R 4 570,62

View Product

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Overview All Projects Project details

Project-27 Untitled

open

| |
|---|
| Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshing |
| |
| BOM Manager Activity Log Documents |
| |
| Add products to Bill of Materials |
| |
| By product reference number # |
| |
| By Excel/CSV file ( Download sample template ) |
| |
| Error adding products View BOM |
| |
| By product segments / selection tools |
| |
| Programmable controllers and I/Os |
| |
| PLC, PAC, IOs and Power supplies |
| |
| Motor Protection & Control |
| |
| VSD, Soft Starter, Direct Starter and protections |
| |
| Human-machine interfaces |

| |
|---|
| HMI panels, controllers, software and Industrial PCs |
| |
| Interface, Safety and Control Relays |
| |
| Electromechanical, Control, Timing and Solid State Relays |
| |
| Enclosures and Accessories |
| |
| Enclosures, thermal management, accessories and cabling |
| |
| Push Buttons, Switches, Pilot Lights and Joysticks |
| |
| Harmony ranges |
| |
| Motion Control and Robotics |
| |
| Move the machine tooling or the part itself in a controlled, rotary or linear manner. |
| |
| Power Control and Protection |
| |

Power supplies and transformers

Software License Configurator

Software License Configurator

Bill of Materials

Total items selected: 0 Total: R 30 687,22

1

Controller, Modicon M171/M172/M173, optimized display 22 IO, Modbus

R 9 888,63

View Product

2

Modicon M171 Optimized LV Connector 1m cable

R 555,78

| |
|---|
| View Product |
| |
| 3 |
| |
| Modicon M171 Optimized AO Connector 1m cable |
| |
| R 140,86 |
| |
| View Product |
| |
| 4 |
| |
| Modicon M171 Optimized AO Connector 2m cable |
| |
| R 201,24 |
| |
| View Product |
| |
| 5 |
| |
| Modicon M171 Optimized Display LED |
| |
| R 1 802,40 |
| |
| View Product |
| |

| |
|---|
| 6 |
| |
| Modicon M171 Optimized Display LCD |
| |
| End of commercialisation: 12/01/2024 |
| |
| R 3 104,58 |
| |
| View Product |
| |
| 7 |
| |
| Modicon M171 Optimized Wall thermostat without backlight |
| |
| R 2 170,34 |
| |
| View Product |
| |
| 8 |
| |
| NTC 1,5m IP68 5x20 -50+110°C Grey |
| |
| R 143,76 |
| |
| View Product |
| |
| 9 |

NTC 1,5m IP68 5x20 -50+110°C Grey

R 136,69

View Product

10

NTC 3,0m IP68 5x20 -50+110°C Grey

End of commercialisation: 12/01/2024

R 229,99

View Product

11

EEV Driver, Actuator

End of commercialisation: 01/23/2021

R 3 449,54

View Product

12

EEV Driver, Autonomous & Hardwired

End of commercialisation: 01/23/2021

R 3 737,01

View Product

13

EEV Driver, Autonomous & Modbus

End of commercialisation: 12/01/2024

R 4 570,62

View Product

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Overview All Projects Project details

Project-27 Untitled

open

Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshing

BOM Manager Activity Log Documents

View :

thesis atlantic car... Successfully Scanned Owner Owner 17/3/2025 17/3/2025 10:09:24 AM Set Date

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Overview All Projects Project details

Project-26 Untitled

open

Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshing

BOM Manager Activity Log Documents

Add products to Bill of Materials

By product reference number #

By Excel/CSV file ( Download sample template )

Error adding products View BOM

| |
|---|
| By product segments / selection tools |
| Programmable controllers and I/Os |
| PLC, PAC, IOs and Power supplies |
| Motor Protection & Control |
| VSD, Soft Starter, Direct Starter and protections |
| Human-machine interfaces |
| HMI panels, controllers, software and Industrial PCs |
| Interface, Safety and Control Relays |
| Electromechanical, Control, Timing and Solid State Relays |
| Enclosures and Accessories |
| Enclosures, thermal management, accessories and cabling |

| |
|---|
| Push Buttons, Switches, Pilot Lights and Joysticks |
| |
| Harmony ranges |
| |
| Motion Control and Robotics |
| |
| Move the machine tooling or the part itself in a controlled, rotary or linear manner. |
| |
| Power Control and Protection |
| |
| Power supplies and transformers |
| |
| Software License Configurator |
| |
| Software License Configurator |
| |
| Bill of Materials |
| |
| Total items selected: 0 Total: R 51 005,44 |
| |
| 1 |
| |

| |
|---|
| Motion controller LMC216 16 axis - Acc kit - Basic |
| |
| End of commercialisation: 12/01/2024 |
| |
| Price Unavailable |
| |
| View Details |
| |
| 2 |
| |
| Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A |
| |
| R 13 112,60 |
| |
| View Product |
| |
| 3 |
| |
| Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control |
| |
| R 1 709,72 |

| |
|---|
| View Product |
| |
| 4 |
| |
| battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SM |
| |
| R 11 849,78 |
| |
| View Product |
| |
| 5 |
| |
| battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SM |
| |
| R 17 709,70 |
| |
| View Product |
| |
| 6 |
| |

| |
|---|
| Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A |
| |
| R 3 679,82 |
| |
| View Product |
| |
| 7 |
| |
| Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah |
| |
| R 2 943,82 |
| |
| View Product |
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Overview All Projects Project details

Project-25 Untitled

open

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BOM Manager Activity Log Documents

Add products to Bill of Materials

By product reference number #

By Excel/CSV file ( Download sample template )

Bill of Materials

Total items selected: 0 Total: R 400 547,09

| |
|---|
| Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A |
| |
| R 14 080,25 |
| |
| View Product |
| |
| 2 |
| |
| Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil |
| |
| End of commercialisation: 12/31/2023 |
| |
| R 28 920,36 |
| |
| View Product |
| |
| 3 |
| |
| variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 |
| |
| R 334 238,57 |
| |

| | |
|---|---|
| | View Product |
| | |
| | 4 |
| | |
| | Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type |
| | |
| | R 1 005,92 |
| | |
| | View Product |
| | |
| | 5 |
| | |
| | Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type |
| | |
| | R 1 005,92 |
| | |
| | View Product |
| | |
| | 6 |
| | |

| |
|---|
| Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type |
| |
| R 1 005,92 |
| |
| View Product |
| |
| 7 |
| |
| torque limiting screws, ComPact NSX400/630, power connections, set of 12 parts |
| |
| End of commercialisation: 12/01/2024 |
| |
| R 489,96 |
| |
| View Product |
| |
| 8 |
| |
| TeSys F - suppressor module - RC circuit - 127...240 V AC |
| |
| End of commercialisation: 12/31/2023 |
| |

| |
|---|
| R 1 344,07 |
| |
| View Product |
| |
| 9 |
| |
| Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 0.3-3s, front, screw clamp terminals |
| |
| R 2 151,05 |
| |
| View Product |
| |
| 10 |
| |
| Time delay contact block,TeSys Deca,1NO+1NC,on-delay 1-30s,front |
| |
| R 2 151,05 |
| |
| View Product |
| |
| 11 |
| |
| TeSys F - main contact set - 3P |
| |

End of commercialisation: 12/31/2023

R 14 154,02

View Product

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Overview All Projects Project details

Project-24 Untitled

open

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Add products to Bill of Materials

By product reference number #

By Excel/CSV file ( Download sample template )

Error adding products View BOM

By product segments / selection tools

Programmable controllers and I/Os

PLC, PAC, IOs and Power supplies

Motor Protection & Control

VSD, Soft Starter, Direct Starter and protections

Human-machine interfaces

HMI panels, controllers, software and Industrial PCs

| | |
|---|---|
| | Interface, Safety and Control Relays |
| | |
| | Electromechanical, Control, Timing and Solid State Relays |
| | |
| | Enclosures and Accessories |
| | |
| | Enclosures, thermal management, accessories and cabling |
| | |
| | Push Buttons, Switches, Pilot Lights and Joysticks |
| | |
| | Harmony ranges |
| | |
| | Motion Control and Robotics |
| | |
| | Move the machine tooling or the part itself in a controlled, rotary or linear manner. |
| | |
| | Power Control and Protection |
| | |
| | Power supplies and transformers |
| | |
| | Software License Configurator |
| | |

| |
|---|
| Software License Configurator |
| |
| Bill of Materials |
| |
| Total items selected: 0 Total: R 110 098,24 |
| |
| 1 |
| |
| Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A |
| |
| R 14 080,25 |
| |
| View Product |
| |
| 2 |
| |
| Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil |
| |
| End of commercialisation: 12/31/2023 |
| |
| R 28 920,36 |
| |
| View Product |

| |
|---|
| 3 |
| soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW |
| R 65 378,96 |
| View Product |
| 4 |
| torque limiting screws, ComPact NSX400/630, power connections, set of 12 parts |
| End of commercialisation: 12/01/2024 |
| R 489,96 |
| View Product |
| 5 |

| |
|---|
| Auxiliary contact block, TeSys Deca, 1NC, front mounting, screw clamp terminals |
| |
| R 277,79 |
| |
| View Product |
| |
| 6 |
| |
| Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals |
| |
| R 350,84 |
| |
| View Product |
| |
| 7 |
| |
| Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals |
| |
| R 600,08 |
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By product segments / selection tools

Programmable controllers and I/Os

PLC, PAC, IOs and Power supplies

Motor Protection & Control

VSD, Soft Starter, Direct Starter and protections

Human-machine interfaces

HMI panels, controllers, software and Industrial PCs

Interface, Safety and Control Relays

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| Electromechanical, Control, Timing and Solid State Relays |
| |
| Enclosures and Accessories |
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| Enclosures, thermal management, accessories and cabling |
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| Push Buttons, Switches, Pilot Lights and Joysticks |
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| Harmony ranges |
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| Motion Control and Robotics |
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| Move the machine tooling or the part itself in a controlled, rotary or linear manner. |
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| Power Control and Protection |
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| Power supplies and transformers |
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| Bill of Materials |
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| Total items selected: 0 Total: R 17 164,53 |
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| 1 |
| |
| Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals |
| |
| Price Unavailable |
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| 2 |
| |
| Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, <=440V, 115A, 230V AC 50/60Hz coil, screw clamp terminals |
| |
| R 9 642,90 |
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|---|
| Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC |
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| 4 |
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| Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC |
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| R 606,49 |
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| View Product |
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| 5 |
| |
| Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 10-180s, front, screw clamp terminals |
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| R 2 393,92 |
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| View Product |
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| 6 |
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| Contactor coil, TeSys Deca, LX1D8, 230V AC 50/60Hz for 115 and 150A contactor |
| |
| R 3 914,73 |
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| PLC, PAC, IOs and Power supplies |
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| Motor Protection & Control |
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| VSD, Soft Starter, Direct Starter and protections |
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Total items selected: 0 Total: R 261 204,87

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License, EcoStruxure Control Expert, service pack base, small S, 1 user, node locked, digital license

R 14 435,28

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License, EcoStruxure Control Expert, with Topology Manager and M580 safety, for XL, node locked, 10 users,

R 246 769,59

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PLC, PAC, IOs and Power supplies

Motor Protection & Control

VSD, Soft Starter, Direct Starter and protections

Human-machine interfaces

HMI panels, controllers, software and Industrial PCs

Interface, Safety and Control Relays

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| Motor Protection & Control |
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| VSD, Soft Starter, Direct Starter and protections |
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| Human-machine interfaces |
| |
| HMI panels, controllers, software and Industrial PCs |
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| license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 |
| R 840,00 |
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| R 777,00 |
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Project 2025.03.17#17898

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ATS22C59S6U

soft starter for asynchronous motor, Altistart 22, control 110V, 230 to 575V, 200 to 500hp

Datasheet

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Project 2025.03.17#17898

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ATS22C59S6U

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Datasheet

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| 1 item(s) selected:Fundamentals of Health Care Facility Electrical Power Systems |
| Course Outline |
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| Course Description |
| With daunting aspects such as ever-changing codes and standards, increasing medical complexity, and |
| dwindling capital budgets, hospitals and health care facilities are among the most challenging building |
| projects. Health care facility electrical systems are complex, difficult to design, expensive to build and |
| subject to a plethora of codes and standards as well as intensely regulated by authorities having jurisdiction |
| over their design and construction. With new medical technologies continuing to arrive on the scene, |
| healthcare facility electrical systems are ever changing. |
| This course provides an introduction to the topic of healthcare facility electrical systems. |
| Course Outline |
| Course Objectives |
| • Recognize the importance of electrical distribution to health care facilities, and how it differs from |
| other types of buildings |
| • Identify the codes, standards and guidelines which govern the design of health care facility |
| electrical systems |
| • Describe the elements of a health care facility’s Essential Electrical System |

| | |
|---|---|
| | Course Content or Material |
| | 1) Introduction |
| | 2) Different types of health care facilities have differing needs and code requirements for electrical distribution |
| | a. Hospitals |
| | b. Long-term care facilities |
| | c. Ambulatory surgery facilities |
| | d. Outpatient therapy facilities |
| | e. Outpatient facilities |
| | f. Clinics and physician offices |
| | 3) The importance of electrical distribution to hospitals |
| | a. Life support |
| | i. Patients on ventilators |
| | ii. General anesthesia |
| | b. Medical procedures |
| | c. Medical records |
| | d. Comfort |
| | e. Life Safety (fire safety) |
| | i. Illumination of the means of egress |
| | f. Without electrical power, a medical facility will close and/or be evacuated. |
| | 4) Codes, standards and guidelines |
| | a. NFPA 101 |
| | Fundamentals of Health Care Facility Electrical Power Systems |
| | Course Outline |
| | © 2015 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective ow |
| | b. NFPA 99 |

| |
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| c. NFPA 110 and 111 |
| d. NFPA 70 |
| e. NFPA 70E |
| i. Electrical safety for those who work on electrical gear |
| f. FGI Guidelines |
| g. CMS |
| h. OSHA |
| 5) Essential Electrical System |
| a. Alternate source of power |
| i. Classification of the emergency power source |
| b. Branches of the essential electrical system |
| i. Example: Type I systems |
| 1. Life Safety Branch |
| 2. Critical Branch |
| 3. Equipment Branch |
| ii. Type 2 and Type 3 systems |
| c. Potential failure points within the essential electrical system |
| 6) Assessing the need for providing an alternate source of power |
| 7) Summary |
| Course Assessment: Test Your Knowledge |
| Course Survey: We Value Your Opinion |
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| Leaderboard |
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| 2350 points 4732nd |
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| 1st level 32nd |
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| 4 badges |
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| 3 completed courses223rd |
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| 3 certificates235th |
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| On Mon, Mar 17, 2025 at 11:18 AM tshingombe fiston <tshingombefiston@gmail.com> wrote: |
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| 0% completed |
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| Rate this course |
| |
| Course rating is 4.76 stars |

By Language / English

Applying Safety Rules

Student

Duration*: 20 minutes*

Outline*:*

In this course, you will learn how to avoid electrical hazards as a professional by ensuring safety on the job sit
concepts of electricity to better understand its dangers and the importance of product sizing.

At the end of this course, you will be able to:

- To define principles safety rules

- To know standard safety equipment and specific PPE

- To memorize gestures and habits to be safe during an intervention

To achieve it, you will get access to a composition of materials as procedure block, flashcards, podcasts, in

Have a good journey!

*This course was made possible thanks to an international collaboration:*

- *Schneider Electric education team ;*
- *Eric Dupont, a teacher affiliated with the French Ministry of National Education ;*
- *ItyCom, a leading provider of digital learning solutions ;*
- *Cécile Lienaux, a graphic designer ;*

| | |
|---|---|
| | |
| | *"Electrical equipment should be installed, operated, services or maintained only by qualified electrical mainten*<br>*out of or in connection with (i) informational content of this course not conforming with or not reaching requir*<br>*basis of or in reliance on any information contained or referred to in this course."* |
| | |
| | Course content |

Additional content has been loaded

Discover personal protective equipment

Top of page

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Applying safety rules

0% COMPLETE

Discover personal protective equipment

Practical case

Electricity risks

Safety rules for working with electrical equipment

Test your knowledge

Conclusion

This lesson is currently unavailable

Must pass quiz before continuing: "Test your knowledge"

Home

Lesson content

Discover personal protective equipment

Lesson 1 of 6

We are happy to have you with us!

To start your safety training, you will learn how to choose the appropriate personal protective equipment in c

Continued

Personal Protective Equipment (PPE)

What is a Personal Protective Equipment (PPE)?

Personal protective equipment (PPE) is an important aspect of electrical safety, as it helps protect workers

Wearing PPE can help prevent injuries and fatalities due to electrical accidents.

It is important for workers to use the appropriate PPE for the task they are performing, and to ensure that

What to wear to be safe during an installation?

Here is a list of basic personal protective equipment:

*Click on each tab below to learn about the different types of personal protective equipment:*

Protect the upper body.

When working on energized systems, do not pull up your sleeves.

This equipment is the standard, but it can change depending on the activities.

63% Completed

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Must pass quiz before continuing: "Test your knowledge"

Lesson 3 of 6

In this chapter you will learn more about electricity to better understand safety issues.

Continued

Electricity and its dangers

Why is it risky?

| | |
|---|---|
| | Electricity is a form of energy resulting from the presence and movement of charged particles, such as electro |
| | |
| | |
| | |
| | It is generated by the movement of charged particles. For example, in a battery, chemical reactions create a fl |
| | |
| | Electricity can be dangerous: |
| | |

| |
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| In most businesses and households, the voltage of the electricity and the available electrical current have “hot”, “energized”, or “live” part of the outlet could kill a person. |
| |
| Analyzing Reliability in the Data Center Outline |
| |
| Course Description: |
| |
| The growing reliance on information systems that operate 24 hours per day, 7 days per week, has |
| |
| spawned a rapidly growing and developing industry that supplies products and services on |
| |

demand. The need for these types of information services now reaches into every business office

in the world. Unfortunately, events of all kinds including hardware failure, human error,

environmental changes, structural failure and external events, can lead to the possibility of

unanticipated systems downtime.

Modern data centers do not tolerate planned downtime and strive for no outages in a 10-year

mission. Data center operations staffs are faced with the dilemma of either downtime as a result of

| |
|---|
| insufficient physical infrastructure, or incurring extensive costs by designing in more redundancies |
| |
| than is necessary. Targeted reliability solutions allow businesses to meet individual requirements of |
| |
| the data center, while minimizing the total cost of ownership. |
| |
| In fact, very high reliability is difficult to attain and redundant hardware is only part of the answer. |
| |
| This course will demonstrate some important performance success factors and overviews best |
| |
| practices for analyzing and optimizing reliability. |
| |
| Course Outline: |
| |
| Learning Objectives |

At the completion of this course, you will be able to:

§ Define key terms associated with analyzing reliability risks

§ Identify some common cause failures in the data center

§ Describe the benefits of conducting a Probabilistic Risk Assessment (PRA)

§ Recognize the reliability advantages of utilizing scalable, modular architecture in the data center

Agenda

§ Introduction

§ Analyzing risk

§ Redundancy

§ Common cause failures

§ Probabilistic Risk Assessment (PRA)

§ Case study example

§ Summary

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1) Introduction

a) Information systems need to operate 24 / 7

b) Growing and developing industry supplies products and services on-demand

c) Modern data centers do not tolerate planned downtime and strive for no outages in a 10-

year mission

d) Data center operations staffs are faced with

e) The dilemma of downtime as a result of insufficient physical infrastructure

f) Incurring extensive costs by factoring in unnecessary redundancies

g) Targeted reliability solutions allow businesses to meet individual requirements of the data

center, while minimizing the total cost of ownership

2) Reliability

a) Understanding how to best define downtime risk

i) Is important to optimizing its reliability

ii) Decreases total cost of ownership

iii) Increases agility

b) Reliability metrics statistically analyze the likelihood of a failure occurring

3) Redundancy

a) While redundancy can increase reliability, there are significant costs and potentially

serious drawbacks

b) A redundant system has more components

c) In general, systems with more components will experience more failures

4) Discussing Best Practices

a) The design, manufacture, operation, maintenance and repair of equipment

b) The gathering of data, and the review and publication of component benchmarking results

c) Consistent deployment of the language of reliability, both definitions and assumptions

d) A philosophy addressing the constant pursuit of root causes, common cause failures and

relevant data

5) Modularity and Component Count

a) Reliability can be increased through standardization

b) Modularity is a powerful concept

c) Modularizing a system can increase the number of internal components

d) Reliability analysis of modular systems must consider

i) Component design

ii) Function

iii) Dependencies

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a) Data center testing and maintenance practices often have a significant impact on systems

reliability

b) Testing and diagnosis can improve reliability, but may also degrade it

7) UPS: Historical Perspective

a) In most UPSs, utility AC power is rectified to DC

b) The inverter synthesizes an AC voltage free from the effects of spikes, sags, harmonics,

and brief utility outages

8) Assessing Reliability

a) Product support engineers

i) Track the products' performance in actual use

ii) Identify and implement changes necessary to correct deficiencies or defects

iii) Benefit from a road map identifying components most likely to fail

b) Deviations from the predictions of the road map would identify new areas for more

| |
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| intensive investigation and possible remedial action |
| |
| 9) The Correct Course of Action: PRA |
| |
| a) The process of building the logical model results in a comprehensive review |
| |
| b) The mathematical nature of the calculation limits the logical fallacies that tend to dominate |
| |
| qualitative evaluation of reliability |
| |
| c) The implication is that if N components are required for success, there is one, two, twice |
| |
| as many, or even twice plus one as many units available |
| |
| d) Not all redundancy makes the same contribution to reliability |
| |
| 10) Reliability Assessment Case Study |

a) The mathematical models that resulted from the analysis were used to answer some key questions

b) The scalable, modular system utilizes redundancy in nearly all components as a means of achieving high reliability

c) MTechnology, Inc's analysis showed that

d) There are both costs and benefits to redundancy

e) Some sub-systems benefit less from redundancy than others

f) Complex mathematical formulas were utilized to calculate the case study failure rates and

common cause failures

11) Case study goals

a) To identify potential sources of failure

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system’s

reliability and availability

12) Target of Case Study Analysis

a) Subjects of analysis

i) 14 - 40 kW Scalable, modular, rack based power system with PDU and static bypass

ii) 500 kW central UPS

b) Tools utilized

i) Probabilistic Risk Assessment (PRA)

ii) Fault tree

iii) Event tree analysis

iv) Bayesian updating

13) Reliability Assessment Case Study

a) All actions have both beneficial and negative affects on reliability

b) It helps to support the uptime of the servers but also can represent a point of failure

14) Comparing Modularity to the Central UPS

a) The scalable, modular system loses power to all loads only when

| |
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| i) The main entrance bus fails |
| |
| ii) The transfer switch fails to open |
| |
| b) The probability of all 14 scalable, modular units failing simultaneously due to internal |
| |
| failures is extremely low |
| |
| c) PDU failure will cause partial load drop |
| |
| d) Only one circuit breaker after the transfer switch will cause all critical loads to fail |
| |
| 15) Central UPS data |
| |
| a) Battery failure is a significant contributor of failure in central UPS |
| |
| b) The central UPS can fail internally, and bypass can fail, causing all loads to fail |

c) PDU failure will cause partial load drop

16) Reliability Assessment Case Study: The Findings

a) The calculated reliability of the scalable, modular power system is comparable to data published by vendors of large, central UPSs

b) The scalable, modular power system is significantly less likely to suffer a complete system failure

c) The redundancy provided in the scalable, modular power system definitely improves the product's reliability

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a) Overall, the scalable, modular architecture had a system failure rate was approximately

40% lower than that of the central UPS system

b) Failure is defined as the loss of power for all critical loads

c) Discounting battery failures, the scalable, modular failure rate is still approximately 18%

less than that of a comparable central UPS architecture

| | |
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| | d) If failure is defined to include dropping of any single load due to a branch circuit failure, but |
| | |
| | not UPS failure, the scalable, modular architecture is 6% less likely to fail |
| | |
| | e) Scalable, modular power system architecture proved more reliable than the single module |
| | |
| | UPS with a single battery string |
| | |
| | f) The redundant subsystems within the scalable, modular power system successfully |
| | |
| | reduced the probability of UPS failure |
| | |
| | g) The performance of the ATS is often the limiting factor in achieving higher reliability |
| | |
| | 18) Summary |

| |
|---|
| a) Understanding how to best define downtime risk is important to optimizing its reliability, |
| while decreasing TCO and increasing agility |
| b) While redundancy can in principle increase reliability, there are significant costs and |
| potentially serious drawbacks |
| c) Data center professionals need to understand which processes are most critical, and |
| target reliability accordingly |
| d) PRA is a powerful tool when applied carefully |
| Course Assessment: Test Your Knowledge |

Course Feedback: We Value Your Opinion

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An Introduction to Medical Gas and Vacuum Systems

Course Outline

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Course Outline

Course Description

This course introduces plumbing and medical gas systems for medical treatment facilities. We will

discuss the various types of medical gas and vacuum systems used in health care facilities.
The

chief purpose of these systems is to provide safe and reliable support to the medical

| | |
|---|---|
| | mission. |
| | Codes and standards are also discussed. |
| | Course Objectives |
| | • Discuss the purpose of plumbing and medical gas systems for medical treatment facilities |
| | • Identify the various types of medical gas and vacuum systems used in health care facilities |
| | • Review the important codes and standards used for medical gas and vacuum systems |
| | Course Content or Material |
| | 1. Introduction |
| | a. Introduction to Medical Gas and Vacuum Systems |
| | 2. Types of medical gas and vacuum systems |
| | a. Medical gas systems |
| | i. Oxygen |
| | ii. Medical Air |
| | iii. Nitrous Oxide |
| | iv. Nitrogen |
| | v. Carbon Dioxide |
| | vi. Mixed Gases |
| | vii. Instrument air |
| | b. Vacuum Systems |
| | c. Medical/Surgical Vacuum |
| | d. Waste Anesthetic Gas Disposal |
| | e. Dental Vacuum Systems (Tim will write a script) |
| | 3. Codes, standards, regulations and authorities having jurisdiction |
| | a. NFPA 99 |

b. FGI Guidelines

c. Local or state regulations

d. Enforcement

i. Certificate of occupancy

ii. CMS and accreditation

e. ASSE Standards

4. Categories of medical gas and vacuum systems

a. Introduction to NFPA 99 Categories

b. Category 1

An Introduction to Medical Gas and Vacuum Systems

Course Outline

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c. Category 2

d. Category 3

Course Assessment: Test Your Knowledge

Course Survey: We Value Your Opinion

On Mon, Mar 17, 2025 at 10:39 AM tshingombe fiston <tshingombefiston@gmail.com> wrote:

We will be conducting system maintenance Sunday March 16, 2025 9:00 p.m.-11:00 p.m. EDT. Please not

Course Assessment - Results page

1

2

3

4

5

6

7

8

9

10

Question

A/n _____ measures the amount of electrical current flowing through a circuit during a specific time interval.

Ampere

Volt

Ohm

Watt

Question

Materials with _____ resistance require more voltage to make the electricity flow.

| |
|---|
| Lower |
| Higher |
| Slower |
| Faster |
| Question |
| True or false? The electrical load in a data center is the sum of the various pieces of data center equipmer |
| T |
| F |
| Question |

The power in Watts is the _____ power drawn by the equipment, while Volt-Amps is called the _____ power.

Electrical, real

Apparent, real

Real, apparent

Real, solar

Question

A circuit breaker may need to switch short circuit currents as high as _____ times its rated current.

30

15

10

5

Question

Circuit breakers can fail in which of the following ways:

Failure to close, or failure to open under fault conditions

Spurious trip

Failure to operate with the time-current specifications for the unit

All of the above

Question

This form of standby power uses electromagnetism to produce electricity

| |
|---|
| a, Electrochemical generator |
| |
| Battery |
| |
| Fuel cell |
| |
| Mechanical generator |
| |
| Question |
| |
| _____ occur when there is a varying quality of connections to the earth at different points in an electrical inst |
| |
| |
| |
| Ground loops |
| |
| Power factor corrected power supplies |
| |
| Ground Fault Circuit Interrupters |
| |
| Thermal-magnetic circuit breakers |
| |
| Question |

An approach to solve the problem of impulsive transients includes the utilization of which device?

Power Line Conditioners

Uninterruptible Power Supply (UPS)

Voltage Surge Suppressor (TVSS)

Modern harmonic-correction equipment

Question

According to M Technology, Inc., what percentage of the time are circuit breakers involved in a power sys

10%

40%

70%

50%

Course Assessment - Test

Course Assessment

Number of questions:

10

Questions are shown:

One by one

So far you have done this test 1 time

Previous unit: Online Course

1.4% completed

Lesson Fundamentals of Power

Course Overview - Passed

Online Course

Course Assessment - Current unit

Reference Materials

Course Transcript

Lesson Going Green: Energy Efficiency in the Data Center

Course Overview

Online Course

Course Assessment

Course Feedback

Reference Materials

Course Transcript

Lesson Building Controls I: An Introduction to Building Controls

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Combined Heat and Power

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Compressed Air Systems I: An Introduction

Course Overview

Online Course

Course Assessment

Course Feedback

Reference Materials

Course Transcript

Lesson Energy Efficiency with Building Automation Systems I

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Energy Procurement I: Options in Regulated and Deregulated Markets

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Energy Procurement II: Introduction to Hedging in Deregulated Markets

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Energy Procurement III: Balanced Hedging Strategies

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Energy Rate Structures I: Concepts and Unit Pricing

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Going Green with Leadership in Energy and Environmental Design

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Maintenance Best Practices for Energy Efficient Facilities

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Steam Systems I: Advantages and Basics of Steam

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Lesson Waste Heat Recovery

Course Overview

Online Course

Course Assessment

Reference Materials

Course Transcript

Previous unit: Online Course

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16) Calculating Efficiency and Operating Costs

a) The technical design of the modular, scalable system results in a much higher efficiency rate running on lightly loaded UPS units

| | |
|---|---|
| | b) The Fortune 500 firm in our case study: |
| | i) Chooses to implement redundant UPS systems and operates each of them at 40% |
| | capacity |
| | ii) Chooses the “install as you grow” approach which accounts for the significant |
| | differences in energy savings, and therefore, lower electrical bills |
| | 17) Total Cost of Ownership |
| | a) Capital costs |
| | i) Allow for an initial build out of 27 watts per square foot for the first 5 years |
| | ii) Assume a build-out to 80 watts per square foot for an additional 5 years |
| | b) Electrical costs |
| | i) Load levels will be at 80% of 2 (N+1) capacity |
| | ii) The maximum loading on any one system is 40% |
| | c) Service costs |
| | i) Customer requires 7x24 |
| | ii) 4 hour response |
| | iii) 100% coverage on parts and labor |
| | iv) Battery maintenance will not be included |
| | 18) Key TCO Components of Payback |
| | 19) Summary |
| | a) The green data center features a safe and healthy work environment and operates in an |
| | energy efficient manner |
| | b) Five examples of green approaches in the data center include the proper use of batteries, |

| |
|---|
| UPSs, rightsized solutions, cooling management, and alternative energy sources. |
| c) TCO analyses can justify investments in green technologies |
| Course Assessment: Test Your Knowledge |
| |
| Course Feedback: We Valu |
| |
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| Fundamentals of Power Outline |
| Course Description |
| Power is the foundational cornerstone in the data center. Many instances of equipment failure, |
| downtime, software and data corruption, are the result of a problematic supply of power. It is |
| imperative that servers are insulated against utility power failures, surges, and other potential |
| electrical problems. This course will explore the topic of power, and how it is utilized within the data |
| center. |
| Course Outline: |
| Learning Objectives |
| • Identify basic electricity concepts |
| • Describe electrical power and its generation |
| • Differentiate between various power usages in a data center |
| • Define power factor |
| • Recognize the importance of electrical safety measures in a data center |

| |
|---|
| • Identify potential problem areas in the data center |
| Agenda |
| • Electrical power key terms |
| • AC and DC power |
| • Power factor |
| • Volt configurations, plugs and receptacles |
| • Circuit breakers and convenience outlets |
| • Seven common electrical problems |
| • Components in a data center |
| Introduction |
| 1) Key Terms |
| a) Volt (V) |
| b) Ampere (Amp) |
| c) Ohm (Ω) |
| d) Hertz (Hz) |
| e) Alternating Current (AC) |
| f) Direct Current (DC) |
| g) Load |
| 2) Single-phase and 3-phase Power |
| 3) Watts and Volt-Amps |
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| 4) Power Factor Correction |
| a) Power factor of nearly 1 |
| b) Method of offsetting inefficiencies created by electrical loads |
| 5) Plugs and Receptacles |
| a) The most common plug/receptacle combination for IT equipment is of an IEC design |

| | |
|---|---|
| | b) Also common are plugs and receptacles of the twist lock variety |
| | 6) International Electro-technical Commission Plugs |
| | 7) National Electric Manufacturers Association Plugs |
| | 8) Circuit Breakers |
| | a) A type of switch |
| | b) Designed to protect electrical equipment from damage caused by overload or short circuit |
| | c) Designed to trip at a given current level |
| | 9) Circuit Breaker Protection |
| | 10) Circuit Breaker Sizing |
| | 11) GFCI, ELCB, and RCD |
| | a) Ground Fault Circuit Interrupters (GFCI), Earth Leakage Circuit Breakers (ELCI), or |
| | Residual-Current Devices (RCD) trip a circuit if they detect a small amount of ground |
| | current |
| | b) Larger data centers use resistor banks instead of GFCI, ELCB, or RCD |
| | 12) Convenience Outlets |
| | a) Used for non-computer devices |
| | b) Allows for other non-computer equipment to be plugged in without taxing the critical load |
| | 13) Grounding |
| | a) Safety measure to protect against electric shock |
| | 14) 7 Power Problems |
| | a) Impulsive Transients |
| | b) Interruptions |

| |
|---|
| c) Sags and Undervoltages |
| d) Swells and Overvoltages |
| e) Waveform Distortion |
| f) Voltage Fluctuations |
| g) Power Frequency Variation |
| 15) Standby Power and Distribution |
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| a) Any power source available to the data center that supplies power when utility power is unavailable |
| 16) Power Distribution Components |
| a) Primary power source (Utility) |
| b) Emergency power source (Generator) |
| c) Circuit/Branch Circuit |
| d) Uninterruptible Power Supply (UPS) |
| e) Automatic Transfer Switch |
| f) Power Distribution Units (PDU) |
| g) Outlet Strips |
| h) Server Plug |
| 17) Summary |
| a) Power infrastructure is critical to uptime |
| b) Understanding basic power terms helps to better evaluate the interaction between the utility, standby power equipment, and load |
| c) Failures can occur at various points in the power infrastructure, but special care should |

| | |
|---|---|
| | be |
| | given to the condition and coordination of circuit breakers |
| | d) Numerous power anomalies exist that can impact the uptime of data center equipment |
| | e) Understanding the threats and applying practical power solutions can help to minimize risk |
| | Course Assessment: Test Your Knowledge |
| | Course Feedback: We Value Your Opinion©2023 Schneider Electric. All rights reserved. All trademarks provid |
| | i. The controlling variable is affected by the actions of the controlled |
| | device upon the controlled variable |
| | c. Cascading |
| | i. Used to modify the performance of closed control loops when |
| | required |
| | 5) Red Wire & Direct Digital Controls |
| | a. DDC |
| | i. More sophisticated system |
| | ii. Use electronic controllers that support multiple control loops |
| | b. Enable / disable control |
| | i. Another form of electronic control |
| | ii. Simply turns another controller on or off |
| | iii. One controller will determine when another controller is able to |
| | perform its function |
| | 6) Summary |
| | a. For an environmental control system to effectively manage the |
| | environment in a building, thereby increasing energy efficiency and |
| | occupant comfort, three things must take place: |

| | |
|---|---|
| | i. Data must be measured and provided as input to the system |
| | ii. Measured data then can be compared to a set of desired outcomes |
| | or instructions |
| | iii. An output is produced based on the measured data to change or |
| | maintain the environment |
| | b. A simple control loop is defined as one input to a controller housing the |
| | control logic, which provides an output to one controlled device |
| | c. Inputs and outputs may be analog or digital |
| | d. A controller may contain many control loops, and a control system may |
| | contain many controllers |
| | e. There are three types of control<br>loops |
| | i. Open |
| | ii. Closed |
| | iii. Cascading |
| | f. And there are three common control technologies |
| | i. Pneumatic |
| | ii. Electrical, and |
| | iii. Electronic |
| | g. Electronic controls may be |
| | i. Direct Digital Control, called DDC, or |
| | ii. Enable / Disable Contro©2023 Schneider Electric. All rights reserved. All trademarks provided are the p |
| | Combined Heat and Power (Cogeneration) |
| | Course Description: Cogeneration today is widely used throughout the world for efficient |

| | |
|---|---|
| | production of heat and power. Cogeneration is the simultaneous production of heat and power in |
| | a single thermodynamic process. The purpose of this course is to review the different approaches |
| | for applying technologies to the function of cogeneration. We'll also explore the various issues |
| | and considerations for deployment of the two main types of cogeneration concepts: "Topping |
| | Cycle" plants (including "Combined Cycle" plants), and "Bottoming Cycle" plants. |
| | Pre-Requisites for this course include: Energy Rate Structures I and II. |
| | Learning Objectives: |
| | At the completion of this course, you will be able to: |
| | • Define what cogeneration is along with the primary fuels used in its creation |
| | • Identify the different approaches for applying technology to the function of cogeneration |
| | • Discuss the various factors to consider when evaluating the use of a CHP plant |
| | Course Content or Material |
| | 1) Introduction |
| | a) Technology overview |
| | b) Defining "cogeneration" |
| | i) How cogeneration occurs |
| | ii) Primary fuels used |
| | 2) Two main approaches for cogeneration technology applications |
| | a) Topping Cycle plants (including Combined Cycle plants) |
| | i) Examples |
| | ii) Overview |

| |
|---|
| b) Bottoming Cycle Plants |
| i) Examples |
| ii) Overview |
| 3) Environmental Issues |
| a) Benefits |
| b) Concerns |
| 4) Things to Consider When Applying CHP Plant |
| a) Steam load versus electric load |
| b) Capital utilization / productivity |
| c) Reliability requirements (steam and electric) |
| d) Local electricity rates |
| e) Efficiency gains versus fuel prices |
| f) Fuel availability and selection |
| g) Staffing and training |
| 5) Comparing CHP Technologies |
| a) Diesel engine |
| b) Natural gas engine |
| c) Steam Turbine |
| d) Gas Turbine©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of t |
| Compressed Air Systems I: An Introduction |
| Course Description |
| Compressed air is widely used throughout industry. It is sometimes called the “fourth utility”, after |
| electricity, gas and water. From mining, lumber and paper mills, petroleum, chemical, textile and glass |

| | |
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| | production to small manufacturing plants and hotels, compressed air provides critical services and can often represent the majority of the facility energy costs. Since many facilities cannot function without compressed air, reliability is paramount, but given that sound operating practices can reduce energy consumption by 20% to 50%, efficiency is high on the agenda. |
| | This is the first in a series of compressed air system courses offered by Energy University. In this course, we will look at the relative inefficiency of compressed air and examine the components of a compressed air system. |
| | Course Outline |
| | Course Objectives |
| | Objectives |
| | • Explain basic compressed air terms and concepts |
| | • Describe the relative inefficiency of compressed air as a power source |
| | • Define the supply and demand sides of a compressed air system and |
| | • Identify the components of a compressed air system and explain what they do |
| | Course Content or Material |
| | 1) Introduction |
| | 2) Supply & Demand |
| | a. Divided into a supply side and a demand side |
| | 3) Compressed Air Pros & Cons |
| | 4) Compressed Air Inefficiency |
| | Examples |
| | a. Metric Unit Example |

| |
|---|
| b. US Customary Unit Example |
| 5) Compressed Air Systems Optimization |
| a. The efficiency of compressed air systems typically receives little attention |
| i. Systems are not well understood by plant operations staff |
| ii. Modifying a system is perceived as a risk to production |
| iii. Vendors compete in a market where equipment is typically sold on a “lowest first bid”, without regard for the cost of operation |
| b. Optimization leads to |
| i. Reduced costs |
| ii. Reduced maintenance |
| iii. Less downtime |
| iv. Increased production |
| v. Improved product quality |
| 6) Equipment Descriptions |
| a. Fan |
| b. Blower |
| c. Compressor |
| 7) Pressure Terminology |
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| a. Pressure |
| b. Absolute Pressure |
| c. Gauge Pressure |
| 8) Standard Volume of Air |
| a. Metric |
| b. US Customary |

| |
|---|
| 9) Volume Flow |
| a. Inlet flow |
| b. Actual flow |
| c. FAD |
| d. Standard flow |
| e. Capacity |
| 10) Operating cost |
| a. Proportional to volume |
| b. Proportional to pressure ratio |
| 11) Dew Point |
| a. The temperature at which condensation begins to occur |
| 12) Compressed Air Requirements |
| a. Cleanliness |
| b. Dryness |
| c. Oil content |
| 13) Compressed Air System Components |
| a. Interactive element |
| 14) Summary |
| a. Basic compressed air terms and concepts; |
| b. Compressed air as a source of power is relatively inefficient. However, it can be very useful and necessary at times; |
| c. Compressed air systems are normally broken down into supply and demand side components; |

| |
|---|
| d. You should now be able to identify basic components of a compressed air system and |
| explain what they do©2023 Schneider Electric. All rights reserved. All trademarks provided are the proper |
| Energy Efficiency with Building Automation Systems Part 1 |
| Course description: |
| In this course we will focus on what a building automation system (BAS) is as well as some of the |
| commonly used terminology. We will also look at some of the HVAC strategies used in building |
| automation systems. |
| Course Outline: |
| Learning objectives |
| At the completion of this course you will be able to: |
| • Define what a building automation system is |
| • Review the main terminology and components of a Building Automation System and |
| HVAC system |
| • List the most common HVAC strategies that may be controlled by a Building Automation |
| System |
| Course content or material |
| 1) Introduction |
| a. What is building automation |
| b. What are the functions of building automation systems (BAS) |
| 2) Parts of a BAS |
| 3) Terminology |
| a. Set point |

| | |
|---|---|
| | b. Air |
| | 4) Review of HVAC systems |
| | a. Equipment |
| | i. Air handling unit |
| | ii. Chiller |
| | iii. Cooling tower |
| | iv. Flow controller |
| | v. Boiler |
| | vi. Dual duct |
| | vii. Constant volume/variable temperature |
| | viii. Variable air volume |
| | ix. Terminal reheat©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of t owners. |
| | Energy Procurement I |
| | Course Description: The procurement of energy (electricity, natural gas, fuel oil, etc.) is |
| | becoming a major part of the energy manager’s job. Cost effective energy procurement requires |
| | understanding of the market, regulatory limitations and opportunities, and contingency planning. |
| | The purpose of this course is to raise awareness of the available options for energy procurement. |
| | Learning Objectives: |
| | ▪ Define the roles of the main players in the energy supply chain |
| | ▪ Explain the major differences in regulated and deregulated markets |
| | ▪ List the main options available for optimizing energy procurement |
| | Course Content or Material: |

| |
|---|
| 1) Introduction |
| 2) Types of Energy Typically Procured |
| a) Most common electricity and natural gas |
| b) Coal, Oil-based fuels, Steam, Compressed air |
| 3) Energy Supply Chain |
| a) Production, Transmission, Distribution, Supply |
| b) Gas supply chain |
| c) Electricity supply chain |
| 4) Regulated and deregulated markets |
| a) Regulated Markets |
| b) De-regulated Markets |
| c) Wholesale versus Retail |
| d) Equal access to transmission and distribution |
| e) Drivers of Deregulation |
| f) Pricing |
| i) in a regulated market |
| ii) in a deregulated market |
| g) Options in a regulated market |
| i) Natural gas contracts |
| ii) Power contracts |
| h) Options in a deregulated market |
| i) Supplier Options |
| i) Local distributor |
| ii) Gas or power marketers |
| iii) Brokers |
| iv) LDC Marketing Departments |
| v) Aggregator |
| vi) Power Pool and Exchange |

| | |
|---|---|
| | Operators |
| | vii) Overview of Supplier Options |
| | viii) Pipeline Connects for Large Consumers |
| | 5) Procurement pitfalls |
| | a) Exposure to energy price volatility that has not been identified or quantified |
| | b) Energy that is managed locally with no corporate oversight |
| | c) Procurement decisions that are made by personnel without knowledge of the energy market |
| | d) Contracts renewed based on expiration, not market conditions |
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| | e) Contract renewals that embed long term risk premiums to vendors |
| | f) A conviction that hedging is speculative in nature |
| | 6) Deregulation Growing and Prices are Volatile |
| | a) Hedging |
| | b) Avoiding pitfalls of lowest price and highest risk©2023 Schneider Electric. All rights reserved. All trademark |
| | Energy Procurement II |
| | Course Description: Unprecedented volatility in today's energy markets has wreaked havoc on the profit margins and bottom lines of many industrial companies. In order to successfully manage costs in this market, it is critical to apply commodity-based market |

| | |
|---|---|
| | purchasing strategies—or as it is commonly known in the industry: “hedging”. Energy |
| | price risk management and hedging programs quantify exposure to adverse events and |
| | mitigate the impact of those events on financial results. An on-going Energy Risk |
| | Management program can provide for more predictable budgeting and insulate future |
| | earnings from the unpredictable effects of volatile energy prices. The purpose of this |
| | course is to address the hedging process. We will also cover the spot and forward |
| | markets as well as fixed and index linked contracts. |
| | Pre-requisites: Energy Procurement I: Options in Regulated and Deregulated Markets. |
| | Learning Objectives: |
| | At the completion of this course, you will be able to: |
| | • Explain the difference between spot and forward markets |
| | • Describe how hedging reduces your risk, and you will be able to |
| | • Define the meaning of fixed and index-linked contracts |
| | Course Content or Material |
| | 1) Introduction |
| | a) Brief overview of gas and electricity markets |
| | b) Energy procurement |
| | 2) Procurement Pitfalls |
| | a) Common pitfalls in a deregulated market |
| | b) How energy managers remedy common errors in energy procurement |
| | 3) Commodity Markets for Energy |

| |
|---|
| a) Commodity exchanges |
| i. The New York Mercantile Exchange (NYMEX) |
| ii. The Singapore Commodity Exchange (SICOM) |
| iii. The former International Petroleum Exchange (IPE) based in London is |
| now part of Intercontinental Exchange (ICE) |
| iv. Over The Counter |
| b) Energy buyer options |
| i. Spot market |
| ii. Forward market |
| i. Fixed contract |
| ii. Index-linked contract |
| 4) Determining Energy Prices |
| a) Total energy costs |
| b) Regulated cost components |
| c) Commodity-based market purchasing strategies |
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| 5) Avoiding Pitfalls of Lowest Price and Highest Risk |
| a) Define energy purchasing strategy |
| i) Spot purchasing versus fixed price purchasing |
| ii) Hedging |
| 6) Implementing Hedging |
| a) Forward contracts |
| b) Futures market |
| c) Flattening a position |
| d) Trading forward contracts |
| e) Permutations |
| f) Contract expiration |

| |
|---|
| g) Imbalances upon delivery |
| 7) Hedging Examples |
| a) Hedging on the forward market |
| b) Settling contracts on the spot market |
| 8) Fundamental Concept of Hedging |
| a) Shaves off the extremes |
| b) Provides predictability |
| 9) Adopting a Balanced Approach to Hedging |
| a) Full requirements fixed-price |
| b) Partial fixed-price |
| c) Partial spot market |
| d) Staggered fixed-price commitments©2021 Schneider Electric. All rights reserved. All trademarks provid |
| Energy Procurement III: Balanced Hedging Strategies |
| Course Description: Managing energy costs is the key to a successful profit margin |
| and bottom line for many industrial companies. In order to successfully manage costs in |
| this market, it is helpful to apply a balanced hedging strategy. A balanced hedging |
| approach will quantify exposure to adverse events and mitigate the impact of those |
| events on financial results. The purpose of this course is to describe a variety of hedging |
| strategies, and identify the main drivers of energy prices. We will also cover how the |
| commodity market functions to support energy trading. |

| |
|---|
| Pre-requisites: Energy Procurement I and Energy Procurement II. |
| Learning Objectives: |
| At the completion of this course, you will be able to: |
| • Describe a variety of balanced hedging strategies |
| • List the main drivers of energy price |
| • Describe how commodity markets function to support energy trading |
| Course Content or Material |
| 1) Adopt a Balanced Hedging Strategy |
| a) Brief overview of concepts covered in Energy Procurement II |
| i) Full requirements fixed-price |
| ii) Partial fixed-price |
| iii) Partial spot market |
| iv) Staggered fixed-price commitments |
| b) Determination requirements |
| i) Commitment term |
| ii) Tolerable price levels |
| iii) Range of tolerable cost fluctuation<br>and |
| iv) Minimum/maximum time horizons for making the next commitment |
| v) Plan of action to mitigate damage for when prices change rapidly |
| 2) Risk Tolerance |
| a) Definition of hedge ratio |
| b) Defining risk tolerance |
| 3) Defining a Hedge Ratio and Strategy |
| a) Riverbanks analogy |
| b) Examples of hedge ratio and energy purchasing strategies |
| 4) Exchange Operation |
| a) How commodity exchanges |

| | |
|---|---|
| | function |
| | b) Commodity exchange regulation |
| | c) Commodity-based market purchasing strategies |
| | 5) Terms and Mechanisms |
| | a) The short position – which means you are agreeing to sell |
| | b) The long position – which means you are agreeing to buy |
| | c) The price of the contract |
| | d) The daily account adjustment |
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| | e) The final settle price |
| | f) The strip |
| | g) Futures market versus the stock market |
| | h) Final settle |
| | 6) Drivers of Energy Prices |
| | a) Supply |
| | b) Demand |
| | c) Seasonality |
| | d) News and Rumors |
| | e) Speculators |
| | 7) Commodity Risk Analysis |
| | a) Role of gas and power marketers |
| | b) Role of independent market analysis service providers |
| | 8) The Forward Curve |
| | a) Definition |
| | b) Examples |
| | 9) Price Forcasting |
| | a) Definition |

| |
|---|
| b) Examples |
| 10) Other Procurement Considerations |
| a) Price, dependability and service |
| b) Importance of considering |
| 11) Best Practices |
| a) Integrates on a continual basis |
| i) Data |
| ii) Risk management |
| iii) Procurement |
| b) Employs |
| i) Data driven decisions |
| ii) Management approach that identifies and quantifies risk before determining |
| the best way to manage it |
| iii) Procurement optimisation with operations |
| 12) Summary |
| |
| 10) Summary |
| |
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| Energy Rate Structures Part 1: Concepts and Unit Pricing |
| Course description: |
| Understanding the forms of energy used at a facility, and the rate structure for each, is |

| | |
|---|---|
| | key to understanding energy costs and implementing an energy efficiency program. By |
| | understanding what you are paying for energy, and how the rate structure controls your |
| | bill, you can adopt different strategies for reducing your energy costs. You may even be |
| | able to move to a different rate structure that is more cost effective for you. In this course, |
| | we will focus primarily on gas and electricity concepts and unit pricing. |
| | Course Outline: |
| | Learning objectives |
| | At the completion of this course you will be able to: |
| | • Define and recognize the difference between consumption and demand |
| | • Identify different forms of energy pricing including |
| | • flat rates, block rates, seasonal pricing, time of use rates, and real time pricing |
| | Course content or material |
| | 1) Introduction |
| | a. Understanding different forms of energy |
| | 2) Consumption and Demand |
| | a. Difference between consumption and demand |
| | b. Example |
| | 3) Energy Pricing |
| | a. Types of energy pricing |
| | i. Flat rate |
| | ii. Block rate |
| | 1. Declining |
| | 2. Inverted |

| |
|---|
| iii. Seasonal rates |
| iv. Time-of-Use rates |
| 1. On-peak |
| 2. Off-peak |
| 3. Shoulder/Mid-peak |
| v. Time of use rates |
| vi. Real Time Pricing |
| vii. Other forms of pricing©2023 Schneider Electric. All rights reserved. All trademarks provided are the prope |
| Going Green with Leadership in Energy and Environmental |
| Design Course Outline |
| Course Description: |
| This course defines green buildings, explains the mission of the US Green |
| Building Council and the requirements of the Leadership in Energy and |
| Environmental Design (LEED) rating system. Schneider Electric solutions for |
| meeting the LEED requirements will also be explained. |
| Course Outline: |
| Learning Objectives |
| At the completion of this course, you will be able to: |
| • Define the characteristics of Green Buildings |
| • Explain the mission of the US Green Building Council |
| • Identify the Leadership in Energy and Environmental Design rating system |
| • Describe Schneider Electric products and services which satisfy LEED |
| requirements |
| Agenda |
| • Introduction |
| • Impacts of US Buildings on the Environment |
| • Advantages of building green |

| |
|---|
| • Review the Mission of the US Green Building Council |
| • Discuss the LEED rating system |
| • Discuss Schneider Electric products and services that satisfy LEED requirements |
| • Introduce Case Studies |
| • Summary |
| Course Content or Material |
| 1) Introduction |
| a) Green Building |
| b) Design of Leadership in Energy and Environmental Design (LEED) |
| c) Who makes up the LEED team |
| d) LEED reach |
| e) Point of the LEED point based system |
| f) Why is there a demand |
| 2) Impacts of US Buildings on the Environment |
| a) Impacts of US buildings on resources |
| b) US Energy Consumption |
| c) US Electricity Consumption |
| 3) Advantages of Building Green |
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| a) Demand for Green Building |
| b) Perceived Business Benefits |
| c) Predictions in growth of Green |
| d) Next Generations impact of perceptions of green build |
| 4) Mission of USGBC |

| | |
|---|---|
| | a) Mission statement for USGBC |
| | b) What the USGBC does |
| | c) Membership |
| | 5) LEED Rating System |
| | a) LEED addresses complete lifecycle of buildings |
| | b) 4 Levels of LEED |
| | c) 6 Credit Categories |
| | d) Steps to LEED Certification |
| | e) A sample checklist |
| | f) Available resources on line |
| | 6) Schneider Electric products and services that satisfy LEED requirements |
| | a) Maximizing LEED points |
| | b) Building Automation and Control |
| | c) Critical Power and Cooling |
| | d) Engineering Services |
| | e) Field Services |
| | f) Lighting and Lighting Controls |
| | g) Power monitoring |
| | h) Variable Frequency Drives |
| | i) Renewable Energy Systems |
| | j) Available Solutions for Compliance |
| | 7) Case Studies |
| | a) Great River Energy Headquarters |
| | b) Genzyme Center |
| | c) Duke Universtiy Smart Home©2023 Schneider Electric. All rights reserved. All trademarks provided are the owners. |

| | |
|---|---|
| | Maintenance Best Practices for Energy Efficient Facilities |
| | Course Outline |
| | Course Description |
| | Good maintenance saves energy costs! Properly maintained facilities and equipment produce |
| | quality products, reduce downtime and have lower energy costs. This adds up to real money! |
| | This course will address the importance of maintenance in facilities, discuss the savings proper |
| | maintenance can contribute, and identify techniques that can lead to the energy efficient |
| | maintenance of facilities. |
| | Course Outline |
| | Course Objectives |
| | • List organizational problems that lead to inadequate maintenance |
| | • Identify the characteristics of an effective maintenance system |
| | • List examples of energy efficiency costs caused by insufficient maintenance |
| | • Calculate the energy costs associated with various types of maintenance failure (eg in |
| | compressed air, steam, etc) |
| | • Identify simple ways that infrared, vibration analysis, and ultrasonic surveys can contribute to |
| | identifying maintenance needs |
| | Course Content or Material |
| | 1) Introduction |
| | 2) Organizational problems |
| | i) Common maintenance problem areas |

| | |
|---|---|
| | (1) Lack of work order system |
| | (2) Poor reporting of work orders / problems |
| | (3) Poor analysis of work orders – (Pareto analysis) |
| | (4) Inadequate preventative maintenance program |
| | (5) Inadequate maintenance training |
| | (6) Poor control of maintenance efforts |
| | (7) Lack of management attention |
| | 3) Characteristics of an effective maintenance system |
| | i) Bring discipline to the maintenance process by ensuring |
| | • Definition of responsibilities |
| | • Adequate training |
| | • Sufficient tools and equipment |
| | • Clear procedures, including evaluation of results, and an emphasis on identifying and reinforcing best practices |
| | ii) These systems can be simple, manual arrangements, or they can include capability for inputs from sensors such as differential pressure across filters, equipment temperatures and vibration |
| | iii) In either case, there are basic requirements for a work order system, work order analysis, generation of maintenance orders, and performance records of equipment. |
| | 4) Examples of energy efficiency costs |
| | i) Steam leaks |
| | ii) Steam trap failures |

| |
|---|
| iii) Compressed air leaks |
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| iv) Uninsulated pipes |
| 5) Tables and charts – Calculating the cost |
| 6) Steam Systems |
| The steam system maintenance should include: |
| Steam Trap Survey and Repair |
| Leak Repair |
| Insulation Repair |
| 7) Compressed Air Systems |
| i) An efficient compressed Air System must include a regularly scheduled ultrasonic leak |
| survey for air leaks. |
| 8) Lighting |
| . |
| Once your solution is defined, your maintenance program should cover: |
| (a) Cleaning |
| (b) Relamping |
| (c) Monitoring compliance with expectations |
| (d) Maintaining standard IESNA light levels |
| 9) Motors |
| a) Use Premium Energy Efficient motors where possible particularly for replacement of |
| failed motors |
| b) Use Variable Speed or Variable Frequency drives |
| c) Use cogged belts or synchronous<br>belts |

| | |
|---|---|
| | i) Properly align motors and drives |
| | (1) Use laser alignment tools for both direct drive and belt drives |
| | (a) This step is crucial to extend motor life. |
| | (i) Design motor bases for easy adjustment |
| | 10) Ultrasonic, Infrared and Vibration Analysis |
| | In the last section of this class, let's look at some specific tools and techniques and see how they |
| | can be usefully applied to the energy-efficiency maintenance of the systems we have been |
| | discussing |
| | a) Ultrasonic Leak detectors |
| | i) Air leaks |
| | (1) Survey for air leaks during full production periods |
| | ii) Steam Traps |
| | (1) Survey steam traps during winter heating season |
| | iii) Specialty gas leaks – especially for high cost gases – Nitrogen, Argon, Carbon |
| | Dioxide |
| | iv) Vacuum system leaks |
| | v) Duct work Leakage– particularly insulated duct work |
| | vi) ID and FD fan duct leakage – particularly behind insulation blankets |
| | vii) Can be used in some production leak testing processes |
| | b) Infrared |
| | i) Infrared inspection equipment is widely available and is astonishing cheap |
| | ii) Electrical gear inspection |
| | iii) Insulation hot spots |

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iv) Roof inspections - Aerial Infrared inspection is a cheap effective method of built up roof inspection especially identifying leak points / saturated insulation

v) Boiler Lagging / Flue Gas Leaks

(1) Infrared inspection can determine point where the leak starts.

c) Vibration Analysis

i) Motors and Bearings

(1) Motor / Drive bases should have a mass that is 3 times the mass of the rotating element. Concrete is a cheap method of adding mass.

ii) Fans

(1) Always dynamically balance fans in place upon installation. Although fans are balanced at the factory, it is common for fans to become damaged and or out of balance during shipment or installation.

iii) Production machinery

(1) Vibration problems usually have one of three solutions - increase mass of the machinery, increase rigidity of the machinery, or dynamically balance the rotating element. Any or all of these methods can be used to reduce or control vibration.

iv) Vibration problems once resolved usually cease to be a problem.

| |
|---|
| v) Large rotating machinery – Often include vibration sensors for continuous condition |
| monitoring |
| Course Assessment: Test Your Knowledge |
| Course Survey: We Value Your Opinion©2023 Schneider Electric. All rights reserved. All trademarks provided |
| Steam Systems I: Advantages and Basics of Steam |
| Course description: |
| Steam has come a long way from its traditional associations with locomotives and the Industrial |
| Revolution. Today, it serves as an integral and essential part of modern technology. This course will |
| introduce the benefits of utilizing steam in numerous processes and discuss t selecting the appropriate |
| pressures for each of these different processes. |
| Course Outline: |
| Learning objectives |
| At the completion of this course you will be able to: |
| ● List the advantages of steam |
| ● Describe the formation of steam |
| ● Understand the relationship between pressure, temperature, and energy |
| Course content or material |
| 1) Introduction |
| a. Advantages of steam |
| b. What is steam |
| c. Definitions |
| i. Joules |
| ii. BTUs |
| iii. Temperature |

| | |
|---|---|
| | iv. Saturation |
| | v. Enthalpy |
| | vi. Absolute pressure |
| | vii. Gauge pressure |
| | viii. Differential pressure |
| | ix. Sensible heat |
| | x. Latent heat |
| | xi. Total heat |
| | 2) Formation of Steam |
| | a. How steam is created |
| | b. Heat energy transfer |
| | i. Example |
| | c. How a boiler makes steam |
| | 3) Relationship between pressure, tem©2023 Schneider Electric. All rights reserved. All trademarks provi |
| | Waste Heat Recovery |
| | Course Description: Waste heat is present in almost all industries and processes. |
| | Opportunities exist to put this waste heat to use economically in order to reduce the |
| | energy consumption in the plant. The purpose of this course is to identify opportunities to |
| | recover waste heat, and the equipment used to recover waste heat. The process for |
| | calculating waste heat recovery will also be addressed, along with the factors that |
| | influence the feasibility of waste heat recovery. |

| |
|---|
| Learning Objectives: |
| At the completion of this course, you will be able to: |
| • List the factors that influence the feasibility of waste heat recovery |
| • Identify opportunities to recover waste heat, the temperature ranges of heat recovered and the possible uses |
| • Perform calculations of waste heat recovery |
| • Categorize and explain the general operation of the main equipment used to recover waste heat |
| Course Content or Material |
| 1) Introduction |
| 2) Benefits of Waste Heat Recovery |
| a) Direct benefits |
| i) Reduced energy consumption |
| ii) Consequent increase in energy efficiency |
| b) Indirect benefits |
| i) Reduction in pollution |
| ii) Reduction in equipment size |
| iii) Reduction in auxiliary energy consumption |
| 3) Factors Influencing Waste Heat Recovery Feasibility |
| a) Sufficient quantity |
| b) Sufficient quality |
| c) Used economically |
| d) Location |
| e) Availability |
| f) Compatibility |
| g) Concerns |
| h) Limits on heat recovery |

| |
|---|
| 4) Waste Heat |
| a) Quality |
| i) Dependent upon the temperature of waste heat available |
| ii) Economic recovery would depend upon following factors: |
| b) Quantity Of Waste Heat |
| i) Quantity of heat (in kcal) = V x ρ x Cp x Δt |
| c) Typical Sources Of Waste Heat |
| i) Heat in waste gases from industrial processes (High temperature) |
| ii) Combustion flue gas (Medium temperature) |
| iii) Low temperature heat recovery |
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| iv) Other sources of waste heat |
| d) Uses of Waste Heat |
| i) Waste heat can be put to use depending upon the type of plant and category |
| of heat available particularly with relation to temperature and quantity |
| ii) Pre heating of combustion air: |
| iii) Pre heating of boiler feed water: |
| iv) Vapour Absorption Refrigeration: |
| v) Pre heating for process<br>requirements: |
| 5) Development Of Waste Heat Recovery System |
| a) Compatibility of waste heat quality: |
| b) Scheduling: |
| c) Location |
| 6) Waste Heat Recovery Devices |
| a) Recuperators |

| | |
|---|---|
| | b) Economizers |
| | c) Waste heat boilers |
| | d) Heat pumps |
| | e) Regenerators |
| | f) Heat Wheels |
| | g) Heat Pipes |
| | h) Other Waste Heat Recovery Devices |
| | 7) Sources and Utilization of Waste Heat Summary Chart |
| | 8) Matrix of Waste Heat Recovery Devices/Applications |
| | 9) Calculating Waste Heat Recovery |
| | a) Overview |
| | b) Case Study Examples |
| | 10) Summary |
| | Course Assessment: Test Your Knowledge |
| | |
| | Course Survey: We Value Your Opinionperature, and energy |
| | |
| | |
| | |
| | 4) Summary |
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d) Schneider Electric and LEEDs

8) Summary

4) Summary

7) Summary

5) Summary

e) Micro-turbine

f) Fuel cells

6) Summary Skip to main content

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Fundamentals of Power Outline

Course Description

Power is the foundational cornerstone in the data center. Many instances of equipment failure,

downtime, software and data corruption, are the result of a problematic supply of power. It is

imperative that servers are insulated against utility power failures, surges, and other potential

electrical problems. This course will explore the topic of power, and how it is utilized within the data center.

Course Outline:

| |
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| Learning Objectives |
| • Identify basic electricity concepts |
| • Describe electrical power and its generation |
| • Differentiate between various power usages in a data center |
| • Define power factor |
| • Recognize the importance of electrical safety measures in a data center |
| • Identify potential problem areas in the data center |
| Agenda |
| • Electrical power key terms |
| • AC and DC power |
| • Power factor |
| • Volt configurations, plugs and receptacles |
| • Circuit breakers and convenience outlets |
| • Seven common electrical problems |
| • Components in a data center |
| Introduction |
| 1) Key Terms |
| a) Volt (V) |
| b) Ampere (Amp) |
| c) Ohm (Ω) |
| d) Hertz (Hz) |
| e) Alternating Current (AC) |
| f) Direct Current (DC) |
| g) Load |
| 2) Single-phase and 3-phase Power |
| 3) Watts and Volt-Amps |
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| | |
|---|---|
| | 4) Power Factor Correction |
| | a) Power factor of nearly 1 |
| | b) Method of offsetting inefficiencies created by electrical loads |
| | 5) Plugs and Receptacles |
| | a) The most common plug/receptacle combination for IT equipment is of an IEC design |
| | b) Also common are plugs and receptacles of the twist lock variety |
| | 6) International Electro-technical Commission Plugs |
| | 7) National Electric Manufacturers Association Plugs |
| | 8) Circuit Breakers |
| | a) A type of switch |
| | b) Designed to protect electrical equipment from damage caused by overload or short circuit |
| | c) Designed to trip at a given current level |
| | 9) Circuit Breaker Protection |
| | 10) Circuit Breaker Sizing |
| | 11) GFCI, ELCB, and RCD |
| | a) Ground Fault Circuit Interrupters (GFCI), Earth Leakage Circuit Breakers (ELCI), or |
| | Residual-Current Devices (RCD) trip a circuit if they detect a small amount of ground current |
| | b) Larger data centers use resistor banks instead of GFCI, ELCB, or RCD |
| | 12) Convenience Outlets |
| | a) Used for non-computer devices |
| | b) Allows for other non-computer equipment to be plugged in without taxing the critical |

| | |
|---|---|
| | load |
| | 13) Grounding |
| | a) Safety measure to protect against electric shock |
| | 14) 7 Power Problems |
| | a) Impulsive Transients |
| | b) Interruptions |
| | c) Sags and Undervoltages |
| | d) Swells and Overvoltages |
| | e) Waveform Distortion |
| | f) Voltage Fluctuations |
| | g) Power Frequency Variation |
| | 15) Standby Power and Distribution |
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| | a) Any power source available to the data center that supplies power when utility power is unavailable |
| | 16) Power Distribution Components |
| | a) Primary power source (Utility) |
| | b) Emergency power source (Generator) |
| | c) Circuit/Branch Circuit |
| | d) Uninterruptible Power Supply (UPS) |
| | e) Automatic Transfer Switch |
| | f) Power Distribution Units (PDU) |
| | g) Outlet Strips |
| | h) Server Plug |
| | 17) Summary |

a) Power infrastructure is critical to uptime

b) Understanding basic power terms helps to better evaluate the interaction between the utility, standby power equipment, and load

c) Failures can occur at various points in the power infrastructure, but special care should be given to the condition and coordination of circuit breakers

d) Numerous power anomalies exist that can impact the uptime of data center equipment

e) Understanding the threats and applying practical power solutions can help to minimize risk

Course Assessment: Test Your Knowledge

Course Feedback: We Value Your Opinion

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Course catalog

System Maintenance: Sunday March 3/16 Time: 9pm-11pm EDT

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We will be conducting system maintenance Sunday March 16, 2025 9:00 p.m.-11:00 p.m. EDT. Please note th

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A Comparison of AC and DC Power Distribution in the Data Center (DC0014EN)

Course rating is 4.559724828017511 stars

By Language / English

A Four-Step Path to a Comprehensive Energy Management Action Plan

Course rating is 4.49519890260631
stars

Uncategorized

Abbott Laboratories Energy Efficiency Development Path

Course rating is 4.434782608695652 stars

By Language / English

Accor Energy Awareness Modules

Course rating is 4.595744680851064 stars

By Language / English

Active Energy Efficiency Using Speed Control

Course rating is 4.63265306122449
stars

By Language / English

AI-Driven Data Centers: Revolutionizing Decarbonization Strategies

Course rating is 4.535714285714286 stars

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Aktive Energieeffizienz durch Drehzahlregelung

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Alternative Power Generation Technologies (DC0003EN)

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| Analyse financière des projets I |
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| Course rating is 4.607843137254902 stars |
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Course rating is 4.670731707317073 stars

By Language / Brazilian Portuguese

Análise Financeira de Projetos I

Course rating is 4.655737704918033 stars

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Aplicación de las normas de seguridad - AEA Standards (YT00014SP)

Course rating is 4.8 stars

By Language / Spanish

Aplicación de las normas de seguridad: México (YT00032ES)

Course rating is 4 stars

By Language / Brazilian Portuguese

Aplicando regras de segurança (YT00026BP)

Course rating is 5 stars

By Language / French

Application des règles de sécurité (YT00022FR)

Course rating is 5 stars

By Language / English

Applying Safety Rules (YT00001EN)

Student

Course rating is 4.764444444444444 stars

By Language / French

Approvisionnement en énergie I

Course rating is 4.295454545454546 stars

By Language / French

Approvisionnement en énergie II

Course rating is 4.636363636363637 stars

By Language / Spanish

Aprender los fundamentos de la electricidad (YT00019ES)

Course rating is 4.631578947368421 stars

Course Catalog

College of Data Center

College of Energy Efficiency

Youth Impact Through Learning

Courses by Topic

Resources

Courses by Language

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Brasileira

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en FranÃ§ais

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On Sun, Mar 16, 2025 at 1:26 PM tshingombe fiston <tshingombefiston@gmail.com> wrote:

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6 Maintenance 9

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| |
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| 7.1 Appendix A: Summary of applicable MTLx541A/AS, MTLx544A/AS Modules 10 - 12 |
| |
| Analogue Input Modules with passive input |
| |
| for 4-wire transmitters |
| |
| Hardware Fault Tolerance |
| |
| (HFT) † |
| |
| Module type 0, 1 |
| |
| MTL4541A, |
| |
| MTL4541AS, |
| |
| MTL5541A, |
| |
| MTL5541AS, |
| |
| MTL4544A, |
| |
| MTL4544AS, |
| |

MTL5544A,

MTL5544AS

† These modules have an inherent fault tolerance of 0.

SIL

IEC 61508:2010

2



# 1 INTRODUCTION

## 1.1 Application and function

The Analogue Input module types MTLx541A/MTLx541AS (single channel) and MTLx544A/MTLx544AS

(dual channel) are intrinsic safety isolators that interface with process measurement transmitters located in

| | |
|---|---|
| | a hazardous area of a process plant. They are also designed and assessed according to IEC 61508 for use in |
| | |
| | safety instrumented systems up to SIL<br>2. |
| | |
| | The MTLx541A provides an input for a separately-powered 4/20mA transmitter located in a hazardous |
| | |
| | area, and repeats the transmitter current into a load in the safe area. The MTLx544A supports two identical |
| | |
| | channels for use with two separate transmitters. The MTLx541AS and MTLx544AS versions act as a current |
| | |
| | sink for the safe area connection rather than driving the current into the load. |
| | |
| | All the modules allow bi–directional transmission of HART communication signals superimposed on the |
| | |

4/20mA loop current, so that the transmitter can be interrogated either from the operator station or by a

held communicator (HHC).

There are no configuration switches or operator controls to be set on the modules. These modules are

members of the MTL4500 and MTL5500 range of products.

1.2 Variant Description

Functionally the MTL4500 and MTL5500 range of modules are the same but differ in the following way:

- the MTL4500 modules are designed for backplane mounted applications

- the MTL5500 modules are designed for DIN-rail mounting.

In both models the hazardous area field-wiring connections (terminals 1,2, and optionally 4,5) are made th

| |
|---|
| |
| the removable blue connectors, but the safe area and power connections for the MTL454xA/MTL454xAS |
| |
| modules are made through the connector on the base, while the MTL554xA/MTL554xAS modules use the |
| |
| removable grey connectors on the top and side of the module. |
| |
| Note that the safe-area connection terminal numbers differ between the backplane and the DIN-rail |
| |
| mounting models. |
| |
| The analogue input models covered by this manual are: |
| |
| Module type Number of channels Safe area connection |
| |
| MTL4541A and 5541A 1 Current source |
| |
| MTL4541AS and 5541AS 1 Current |

| | |
|---|---|
| | sink |
| | |
| | MTL4544A and 5544A 2 Current source |
| | |
| | MTL4544AS and 5544AS 2 Current sink |
| | |
| | Note: To avoid repetition, further use of MTLx54xA and MTLx54xAS in this document can be understood to |
| | |
| | include both DIN-rail and backplane models. Individual model numbers will be used only where there is a |
| | |
| | to distinguish between them. |
| | |
| | All the module types described in this manual have the same connectivity for the field signals, supporting |
| | |
| | 4-wire process transmitters or currents sourced in the hazardous area. The connection of the repeated cu |
| | |

| |
|---|
| signals into the input measurement channels for the safety logic system follows the arrangement shown in th |
| |
| following diagram. When the input channels of the Safety Instrumented System (SIS) are providing power for |
| |
| the loop, the ‘S’ variants of the isolator modules are used to ‘sink’ the measuring current. |
| |
| In the other cases the isolator modules ‘source’ the measuring current that flows into a load resistor inside th |
| |
| input card of the Safety Instrumented System. |
| |
| 4SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 |
| |
| 2+ |
| |
| 1- |
| |
| Pwr |

| |
|---|
| 0V |
| 24V |
| Safety Instrumented |
| System (SIS) |
| Logic Solver with ‘Passive’ |
| input |
| MTLx541A/ |
| MTLx544A |
| (Safe area current source) |
| B |
| A |
| 2+ |
| 1- |
| Pwr |

| |
|---|
| 0V |
| 24V |
| Safety Instrumented |
| System (SIS) |
| Logic Solver with 2-wire input |
| A |
| B |
| Current |
| limiter |
| Output |
| terminal |
| MTL4541A, |
| MTL4541AS |
| MTL5541A, MTL5541AS |

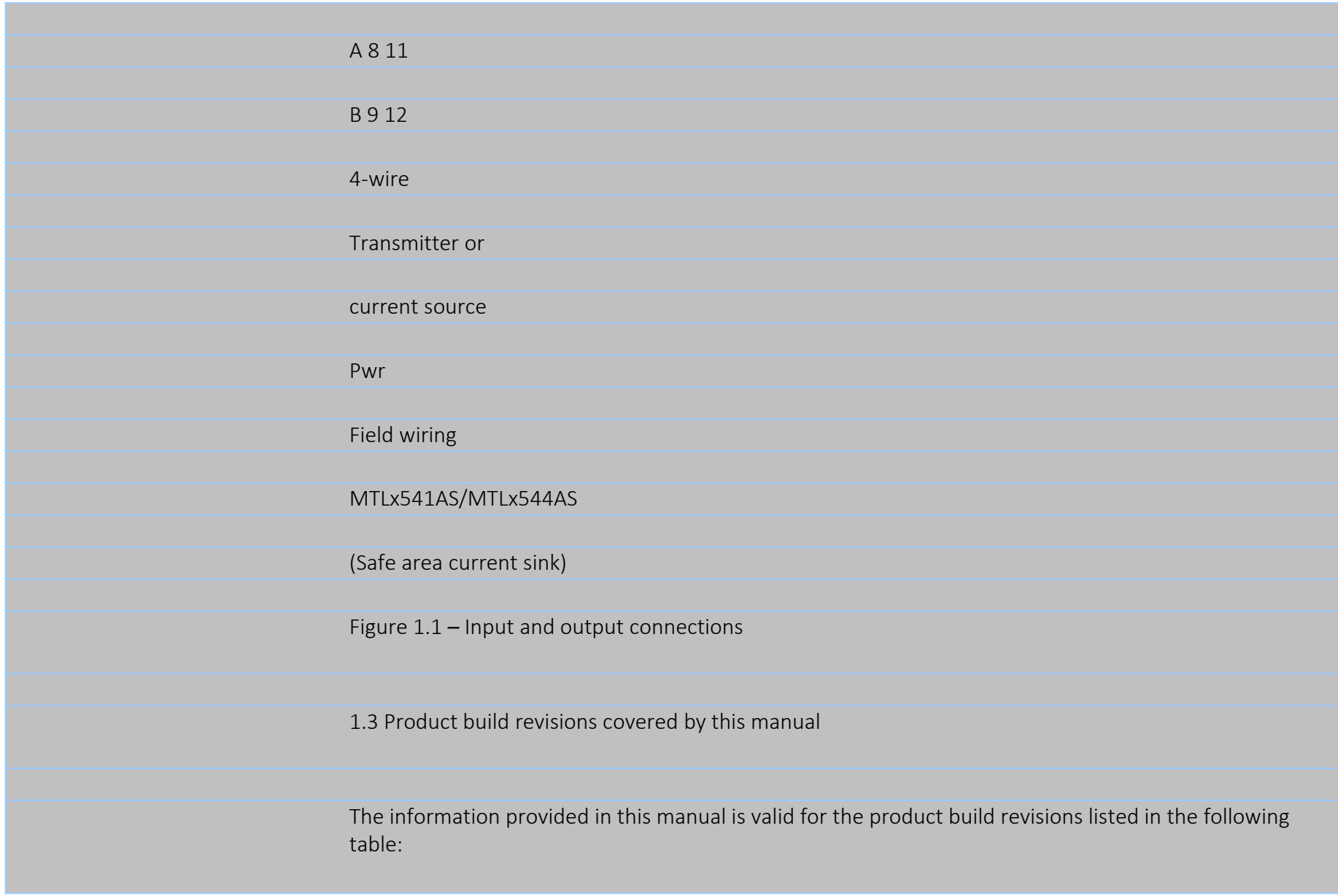



Figure 1.1 – Input and output connections

## 1.3 Product build revisions covered by this manual

The information provided in this manual is valid for the product build revisions listed in the following table:

| |
|---|
| Model Type Product build revision covered by this manual |
| MTL4541A Up to and including 08 |
| MTL4541AS Up to and including 08 |
| MTL5541A Up to and including 08 |
| MTL5541AS Up to and including 08 |
| MTL4544A Up to and including 08 |
| MTL4544AS Up to and including 08 |
| MTL5544A Up to and including 08 |
| MTL5544AS Up to and including 08 |
| The product build revision is identified by the field ‘CC’ in the module Product Identification Number that |
| appears at the bottom left-hand corner of the side label: |

| |
|---|
| The CC field immediately precedes the 7-digit Serial Number field, DDDDDDD. Example: |
| |
| 5SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 |
| |
| 2 System configuration |
| |
| An MTLx54x module may be used in single-channel (1oo1) safety functions up to SIL 2. The worked example |
| |
| in this manual is for a SIL 2 application. |
| |
| The figure below shows the system configuration and specifies detailed interfaces to the safety-related and |
| |
| non safety-related system components. It does not aim to show all details of the internal module structure, |
| |
| but is intended to support understanding for the application. |
| |
| Figure 2 – System Configuration |

The MTLx54xA/MTLx54xAS modules are designed to receive an active 4-20mA signal from separately

powered process transmitters in the hazardous area and to repeat the current flowing in the field loop to the

safe-area load. The shaded area indicates the safety-related system connection, while the power supply con-

nections are not safety-related. The term ‘Logic Solver’ has been used to denote the safety system performing

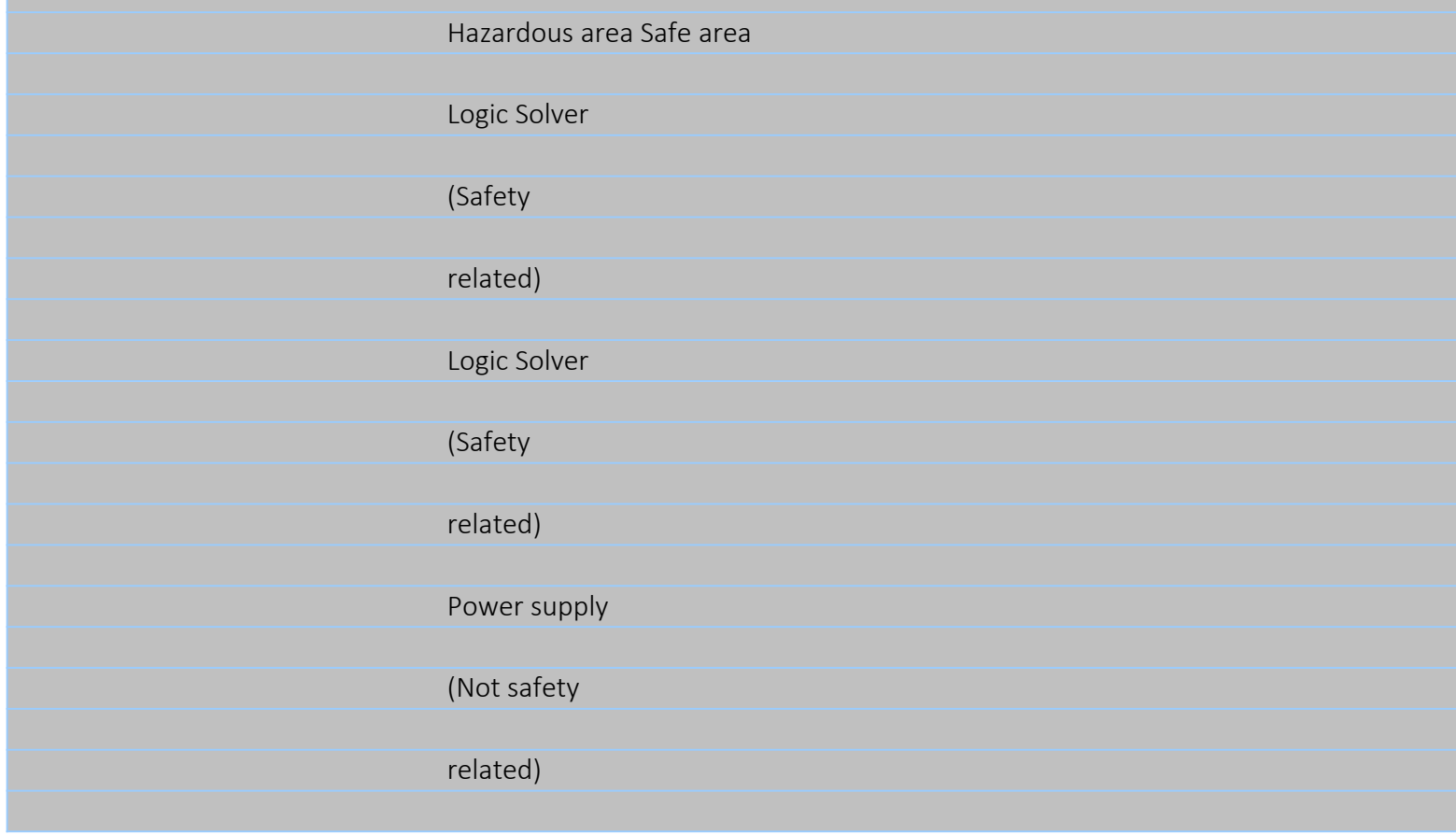
the monitoring function of the process loop variable.

Note: When using the MTLx544A/MTLx544AS dual-channel modules, it is not appropriate for both channels

to be used in the same loop, or the same safety function, as this creates concerns regarding common-cause

failures. Consideration must also be given to the effect of common-cause failures when both loops of a du

channel module are used for different safety functions.



MTL5544A/MTL5544AS (2-channel version) shown.

MTL5541A/MTL5541AS (single-channel version) omits Ch 2.

20 - 35V dc

6SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2

2.1 Associated System Components

There are many parallels between the loop components that must be assessed for intrinsic safety as well as

functional safety. In both situations the contribution of each part is considered in relation to the whole.

The MTLx54xA/MTLx54xAS modules are components in the signal path between safety-related process trans-

mitters and safety-related control systems. The transmitter or other field device must be suitable for the proc

| | |
|---|---|
| | |
| | and have been assessed and independently verified for use in functional safety applications. |
| | |
| | The field instrument and Analogue input card of the Logic Solver shall have a normal operating range of 4- |
| | |
| | but be capable of working over an extended range of 3 to 22mA for under- and over-range. The Logic Solv |
| | |
| | have the ability to detect and annunciate input currents higher than the threshold of 21mA and lower tha |
| | |
| | threshold of 3.6mA to determine out-of-range conditions. |
| | |
| | Note that the transmission of HART data is not considered as part of the safety function and is excluded fr |
| | |

this analysis. However, for HART data communication to take place, the input impedance of the receiving equ

ment must be at least 240R.

3 Selection of product and implications

The safe area output signal from the MTLx541A/AS and MTLx544A/AS modules is within the operating range

4-20mA under normal conditions. If the field wiring to the transmitter or connection between the isolator and

solver is open-circuit then the loop current will fall to less than 3.6mA and close to zero. If the field wiring con

between the transmitter and isolator is short-circuited, the loop current will also fall to below 3.6mA.

| |
|---|
| For module types MTLx541A and MTLx544A that source the 4-20mA signal in the safe area circuit, then th |
| |
| seen by the logic solver will fall to less than 3.6mA and close to zero if the connection between the isolato |
| |
| solver is shorted. |
| |
| For module types MTLx541AS and MTLx544AS that sink the 4-20mA signal in the safe area circuit, then th |
| |
| seen by the logic solver will rise to a value greater than 21mA if the connection between the isolator and l |
| |
| is shorted. |
| |
| In both cases, the fault condition must be detected by the logic solver in Functional Safety applications. Th |
| |

| | |
|---|---|
| | also include the detection of power supply failures which cause the output of the isolator to fall to zero mA. |
| | |
| | 4 Assessment of Functional Safety |
| | |
| | 4.1 Hardware Safety Integrity |
| | |
| | The hardware assessment shows that MTLx541A/MTLx541AS and MTLx544A/MTLx544AS modules: |
| | |
| | • have a hardware fault tolerance (HFT) of 0 |
| | |
| | • are classified as Type A devices (“non-complex” component with well-defined failure modes) |
| | |
| | • have no internal diagnostic elements |
| | |
| | The failure rates of these modules at an ambient temperature of 45°C are as follows: |
| | |
| | Failure mode |
| | |
| | Failure rate (FIT)* |

| |
|---|
| MTL4541A |
| MTL5541A |
| MTL4541AS |
| MTL5541AS |
| MTL4544A |
| MTL5544A |
| MTL4544AS |
| MTL5544AS |
| Output current >21mA (upscale) 3 3 3<br>14 |
| Output current <3.6mA (downscale) 224 224 264 253 |
| Output current within range but >2% in error 42 42 49 49 |
| Output current correct within ±2% 73 73 80 81 |

*(FITs means failures per 109 hours or failures per thousand million hours)

• Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook.

• Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery.

• Stated failure rates for dual-channel modules apply to a single channel.

It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambien

temperature of 45°C.

7SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2

4.2 Systematic Safety Integrity

| |
|---|
| The MTLx54x modules have a systematic safety integrity measure of SC 2. This has been established using |
| |
| compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. |
| |
| 4.3 SIL Capability |
| |
| Considering both the hardware safety integrity and the systematic capability, this allows the modules to be |
| |
| used in safety functions up to SIL 2 in a simplex architecture (HFT=0), provided SFF ≥60% is the case for the |
| |
| application. The hardware safety integrity assessment has been conducted according to compliance Route |
| |
| as described in IEC 61508-2:2010, section 7.4.4. (See example below). |
| |
| Note: |
| |

• Independent of hardware architecture and systematic capability considerations, the hardware probability of

failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for

high or continuous demand safety function) or PFDAVG (for a low demand safety function) for the SIL is met.

4.4 Example of use in a safety function

In this example, the application context is assumed to be:

• the safety function is to repeat current within ±2%

• the logic solver will diagnose currents above 21mA and below 3.6mA as faults and take appropriate

action

The failure modes shown above can then be defined as:

Failure mode Category

Output current >21mA (upscale) Dangerous detected, dd

Output current <3.6mA (downscale) Dangerous detected, dd

Output current within range but >2% in error Dangerous undetected, du

Output current correct within ±2% No effect, ne*

The failure rates of the MTL4541A and MTL5541A for these categories are then (FITs):

| Model | sd | su | dd | du | ne* |
|---|---|---|---|---|---|
| MTL4541A or MTL5541A | 0 | 0 | 227 | 42 | 73 |

In this example, the safe failure fraction (SFF) is 84.4%.

* ne is not used in the calculation of SFF. Defining the “output current correct within ±2%” failure mode as

ne represents a conservative approach to the calculation of SFF. Interpreting this failure mode as su (safe,

undetected) may also be considered and yields an SFF value of 87.7%.

Accordingly, the SFF of all module types described in this manual, when used in the same application,

are as follows:

| Model | sd | su | dd | du | ne | SFF |
|---|---|---|---|---|---|---|
| MTL4541A, MTL5541A, MTL4541AS, | | | | | | |
| MTL5541AS | 0 | 0 | 227 | 42 | 73 | 84.4% |
| MTL4544A, MTL5544A | 0 | 0 | 267 | 49 | 80 | 84.5% |

| |
|---|
| MTL5544AS, MTL5544AS 0 0 267 49 81 84.5% |
| 8SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 |
| 4.5 EMC |
| The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic env |
| ment but, to support good practice, modules should be mounted without being subjected to undue condu |
| or radiated interference, see Appendix A for applicable standards and levels. |
| 4.6 Environmental |
| The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up |
| 95% non-condensing relative<br>humidity. |

| |
|---|
| The modules are intended to be mounted in a normal industrial environment without excessive vibration, as |
| |
| specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels. |
| |
| Continued reliable operation will be assured if the exposure to temperature and vibration are within the value |
| |
| 3- Auxiliary Powers Systems |
| |
| 4- Passenger Stations |
| |
| 5- eBus Depots |
| |
| 6- Tunnel Systems |
| |
| 7- Depots and Workshops |
| |
| 8- Control Center |
| |
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and Urban Transportation Market

SECTION 4 – Design Considerations

SECTION 5 – Customer Stories

The objective of this section is to:

• Introduce traction substations

• Review EcoStruxure Power value propositions and the associated applications for traction

| |
|---|
| substations |
| |
| • Provide reference electrical |
| |
| and digital architectures |
| |
| EcoStruxure Power |
| |
| Digital Solutions and Services |
| |
| for: |
| |
| à Traction Substations |
| |
| Reference Guide |
| |
| EcoStruxure Power for |
| |
| Railway and Urban Transportation |
| |
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| |
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| and Services across the Facilities |
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| |

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What is it?

Introduction to Traction Substations

• Electrical Traction Substations are responsible for supplying trains with electrical energy.

• These facilities manage approximately 75% of the electricity consumption of the entire railway system

• They have a direct impact on the reliability and punctuality of railway traffic.

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How does it work?

Introduction to Traction Substations

| |
|---|
| Energy incomers Traction |
| transformers |
| Feeders |
| Auxiliary |
| systems |
| The Traction Substations are located at regular intervals (depending on AC or DC systems) along the railway. |
| Their main elements are energy incomers, traction transformers, rectifiers (for DC only), feeders and a systems. |
| Traction transformers and rectifiers |
| (the latter for DC configurations) convert |
| electrical parameters to the energy input |

needs of the traction system.

Auxiliary systems

are necessary

for the operation

of the facility.

Feeders provide

energy to the

overhead line

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Two types of traction substations, depending on the type of traction

Introduction to Traction Substations

Overhead

Line

Railway

25kV

It is most common in Urban Transportation.

| |
|---|
| è Catenary supply voltage = 600V-<br>3.3kV |
| |
| Railway Urban Transportation |
| |
| Overhead |
| |
| Line |
| |
| Railway |
| |
| 3.3kV |
| |
| 0.6kV |
| |
| ~ |
| |
| Type 1: Alternating Current Supply Type 2: Direct Current Supply |
| |
| Traction |
| |
| Transformer |
| |
| Overhead |
| |
| Line |

Railway

25kV

50kV

Feeder

Energy Flow

This is most common in Railway.

è Catenary supply voltage = usually 25kV, sometimes 15kV

è Two electrical configurations, depending on the number of phases

in the secondary of the traction transformer:

- 1x25 kV
- 2x25 kV

Comparison of Current Supplies

Public

Direct Current (DC)Alternating Current (AC)

Supply

The overhead line is supplied with AC

current with the following configuration:

• Single phase connected to the overhead line

• Current returns through a return path

Advantages

• Simple configuration. No need of intermediate transformer stations

• No need of feeder cable

Supply

The overhead line is supplied with AC current with

the following configuration:

- One phase connected to the overhead
- The other phase connected to a feeder

conductor

Phases are 180 degrees out of phase

resulting in voltage up to 50 kV voltage.

Advantages

- Higher energy capacity
- Fewer traction substations needed

(but requires more simple intermediate

| |
|---|
| transformer stations) |
| |
| • Reduced electromagnetic interferences |
| |
| Single-phase System (1x25 kV) Two-phase System (2x25 kV) |
| |
| Main Application |
| |
| Urban transportation: metro, light rail, tramways |
| |
| Catenary supply voltage |
| |
| 600V- 3.3kV |
| |
| Supply |
| |
| The traction system provides DC current to the |
| |
| overhead line. |
| |
| The conversion to direct current requires the use of: |
| |

| |
|---|
| • Non-linear power electronic components |
| |
| (rectifiers), |
| |
| • Three-winding voltage transformers |
| |
| • Medium voltage feeder panels |
| |
| • Electric protections specially adapted to this mode |
| |
| Advantages |
| |
| • Possibility to power a section with two sources |
| |
| in parallel |
| |
| • Large installed base, making extensions easier |
| |
| if the rest of the line also uses DC current |
| |
| • Better regulation of motor speed (before the |
| |

| |
|---|
| advent of power electronics) |
| |
| Main Application |
| |
| Mainlines, high-speed lines |
| |
| Catenary supply voltage |
| |
| Usually 25kV, sometimes 15kV |
| |
| Comparison of Current Supplies |
| |
| Depending on the installation, the overhead line is powered with a Direct Current (DC) or Alternating |
| |
| Reference Guide |
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Main components of the electrical architecture

Introduction to Traction Substations

Type 1: Alternating Current Supply Type 2: Direct Current Supply

Type 1 Substation

(Majorly used in Railway)

| |
|---|
| It demonstrates an alternating current (AC) |
| |
| design in a single/two-phase configuration, with |
| |
| an Intelligent Electronic Devices (IEDs)-based |
| |
| control system. |
| |
| Type 2 Substation |
| |
| (Majorly used in Urban Transportation) |
| |
| It demonstrates direct current (DC) design with a |
| |
| PLC-based control system. |
| |
| Public Main Components for Type 1 Alternating Current Supply Traction Substations |
| |
| Public Main Components for Type 2 DC Current Supply Traction Substations |
| |

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2. Operational Management

| |
|---|
| Real-time monitoring and control of power system status and |
| |
| identification of abnormal temperature, insulation faults, |
| |
| power disturbances, etc. |
| |
| The Power System Simulation Engine helps train operators |
| |
| and simulate the effects of switching or maintenance |
| |
| operations before the actual operation is performed |
| |
| 3. Analysis & Optimization |
| |
| • Cloud-based predictive power asset maintenance with |
| |
| expert recommendation provided by our Schneider |
| |
| Electric service experts |
| |

| |
|---|
| • Consulting Services including network and power quality |
| |
| audits |
| |
| • Augmented reality guidance for complicated or rarely |
| |
| 1. Primary Equipment |
| |
| Protection, control, metering, UPS and other equipment used |
| |
| in Traction Substations. These are described in more detail in |
| |
| the following pages |
| |
| EcoStruxure Power Value Proposition |
| |
| Apps, |
| |
| analytics, |
| |
| and services |
| |
| Edge |
| |

Control

Connected

products

for Traction Substations

Cloud-Based Advisor Services for asset management, data integrity

and workforce empowerment with extended reality guidance

Power quality

meter

Protection

relay

Circuit

breaker

Control

| |
|---|
| unit |
| |
| Cooling |
| |
| DC protection |
| |
| relay |
| |
| (Third party) |
| |
| Gateway |
| |
| UPS Protection |
| |
| device |
| |
| Panel |
| |
| server |
| |
| Power |
| |
| quality |
| |
| solutions |
| |
| AVEVA |
| |

System Platform

EcoStruxure

Power Automation

System

EcoStruxure

Power Operation /

Power Monitoring Expert Simulation Engine

Our solution to control and supply energy to traction substations

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Specific pillars for traction substations

EcoStruxure Power Value Proposition

EcoStruxure Power provides applications to support the challenges of Traction Substations for Railway and Urban Transportation, with the following pillars:

Reliable

| |
|---|
| Electrification |
| |
| Electrical Distribution |
| |
| Monitoring and Alarming |
| |
| Capacity Management |
| |
| Power Event Analysis |
| |
| Power Quality Monitoring, |
| |
| Correction, and Compliance |
| |
| Advanced Protection and Automation |
| |
| Safety and Comfort |
| |
| Enhance safety and comfort in |
| |
| passenger stations and tunnels |
| |
| Continuous Thermal Monitoring |
| |
| Guided Procedures Through |
| |
| Extended Reality |
| |

| |
|---|
| Digitalization |
| |
| Operate centrally and |
| |
| maintain infrastructure efficiently |
| |
| Backup Power Testing |
| |
| Circuit Breaker Settings Monitoring |
| |
| |
|

encyclopedia

An electrical grid may have many types of generators and loads; generators must be

ways that led to separate companies handling transmission and distribution.[2]

## System

A diagram of an electric power system. The transmission system is in blue.

| | | | |
|---|---|---|---|
| | Description of project final | y/n | |
| | | | |

| | | | |
|---|---|---|---|
| | A cover page | | |
| | | | |
| | | | |
| | An Abstract | | |
| | | | |
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| | Review of theLiterature | | |
| | Middle Chapters | | |
| | | | |
| | , Chapter Structures | | |
| | | | |
| | , Materials and Methods | | |
| | | | |
| | , Investigative Theories | | |
| | Results, | | |
| | | | |
| | Discussions, | | |
| | | | |
| | Conclusions, | | |
| | | | |
| | Bibliography, | | |
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Appendices

## 3.4.1. PROPOSAL OF THESIS CONTENT AND/OR FINAL PROJECT

This will show you the steps to submit the content of your Thesis or Final Project to our

Academic Staff. We recommend you follow the thesis recommendations on the

following pages, that at a declarative level, but not be limited to, can contain:

- NAME OF THE THESIS (title page)
- INDEX
- INTRODUCTION

• DESCRIPTION

• GENERAL ANALYSIS

• CURRENT INFORMATION

• DISCUSSIONS

• CONCLUSIONS

• BIBLIOGRAPHY



3.4.2. FINAL THESIS OUTLINE

Below you will find two outlines to help you with your thesis. The first one is less detailed than the second one, but both provide a general outline with guidelines to direct you to write a successful thesis:

Thesis Outline #1

| | | | |
|---|---|---|---|
| | | | |
| | Acknowledgements (to people who helped you) | | |
| | | | |
| | Abstract (a short summary of your thesis) | | |
| | | | |
| | Chapter 1: General Introduction | | |
| | | | |
| | Contextual Data | | |
| | | | |
| | Background Information | | |
| | | | |
| | Chapter 2: Definition of the Investigation (or Issue) | | |
| | | | |
| | Statement of the Issue | | |
| | | | |
| | Description of the Issue | | |
| | | | |
| | Chapter 3: Dynamics of the Anticipated Solution | | |
| | | | |
| | Goal(s) and Objective(s) of the Investigation | | |
| | | | |
| | Methodology | | |
| | | | |

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|---|---|---|---|
| | Chapter 4: Overall Outcomes | | |
| | | | |
| | Strategy and Techniques | | |
| | | | |
| | Results | | |
| | | | |
| | Chapter 5: Analysis | | |
| | | | |
| | Interpretation of Results | | |
| | | | |
| | Questions about alternatives | | |
| | | | |
| | Chapter 6: Conclusion | | |
| | | | |
| | General Discussions | | |
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| | Recommendations | | |
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| | Appendices | | |
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| | While the above outline may be modified, it is highly recommended that you use the | | |
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| | outline, though you should change, add, or remove wherever you find it appropriate. | |
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| | Thesis Outline #2 | |
| | | |
| | I. Introduction | |
| | | |
| | • Definition of the notion/concept of modernity (an explanation of the key term) | |
| | | |
| | • Introduction of the topic (what specific topic will be featured?) | |
| | | |
| | • The issue being debated (what specific aspect of the topic will be considered?) | |
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| | II. Elements of procedures | |
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| | • Presentation of the methodology (the modalities of the debate) | |
| | | |
| | • Choice of the variables (an overview of ways data will be manipulated) | |

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| | • Possible Outcomes (a hypothesis) | | |
| | | | |
| | III. Review of the Literature | | |
| | | | |
| | • Past Literature (what old authors have said on the topic?) | | |
| | | | |
| | • Modern Literature (what contemporary authors have said on the topic?) | | |
| | | | |
| | • A Comparative Reading (a possible comparison of the two) | | |
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| | IV. Detailed Analysis | | |
| | | | |
| | • The Actual Process | | |
| | | | |
| | • Illustrations | | |
| | | | |
| | • Preliminary Results | | |
| | | | |
| | V. Overall Outcomes | | |
| | | | |
| | • The Actual Results | | |
| | | | |
| | • Interpretations of Results | | |

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|---|---|---|---|
| | • Link to Real Life | | |
| | | | |
| | VI. Analysis | | |
| | | | |
| | • Isolated Analysis | | |
| | | | |
| | • Comparative Analysis | | |
| | | | |
| | • Questions about alternatives | | |
| | | | |
| | VII. Conclusion | | |
| | | | |
| | • General Discussions | | |
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| | • Recommendations | | |
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What are S1, S2,and S3 in the LH4N2 wiring diagram?

**Issue:**

S1, S2 and S3 buttons wiring diagram indication in LH4N2.

**Product Line:**

LH4N

**Environment:**

All

Cause:

**Control wiring circuit**

**Resolution:**

The S1, S2, and S3 are switch designations in the recommended wiring schemes. When these switches are wired as indicated the S1 is for freewheel stop

Released for:Schneider Electric South Africa

**Attachment(s)**

LH4N Soft Starter Installation Manual.pdf [143.1 KB]

Published on:2006/11/07Last Modified on:2022/04/01

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Explanation of Voltage and Current Input Wiring Diagram for ION8650/8600 Form 35 and 35S, 4-Wire WYE, 2 PTs, 3 CTs

**Issue**

When the ION8650 is set to 35 or 35S, 4-Wire WYE, 2 PTs, 3 CTs, the meter does not seem to read correctly.

**Product Line**

ION8650

ION8600

**Environment**

System Setup

**Resolution**

*****This configuration can affect some of the meters parameter calculations. Contact Schneider Electric for details.*****

This configuration will work for measuring total power. When an ION8650/8600 series meter is applied in this way, some of the many parameter
Mode works.

**Please note: The following setup does not work for unbalanced systems.**

**1. Phase to Neutral Voltages**

Will not be displayed, because DELTA mode does not display line-to-neutral voltages.

**2. Phase to Phase Voltages**

Vab and Vbc will display **phase to neutral voltages**. Vca will correctly show the phase-to-phase voltage. Vll avg will be incorrect.

**3. Current**

Since the CT secondary windings are delta connected, the displayed Ib value is ?(3) * ?(3) or 3 times larger than Ia and Ic. Where Ia = ?(3)I1 the primary.

**4. Real Power**

The kW total will be correct.

**5. Reactive Power**

The kVAr total will be correct.

**6. Apparent Power**

The kVA total will be correct.

**7. Power Factor**

The PF total will be correct.

**Summary for Delta Mode:**

| Valid | Not Valid |
|---|---|
| Vca | Vab, Vbc,- Incorrectly shows Vln values |
| kW tot | Vll avg - Incorrect |
| kVAr tot | Ia, Ib, Ic - Incorrect |
| kVA tot | |

| | |
|---|---|
| pf tot | |

How do I connect / wire a contactor and overload to create a Direct On Line (DOL) Starter?

Attached is a .pdf file with pictorial diagrams [(1)] of how you would connect the four most common variants of a DOL starter.

They show diagrams for 240 and 415 VAC control. The most common for small Direct On-Line Starters (DOLs) is 415VAC, as this requires no
the starter.

Options are also given for using either a remote stop switch or for using the stop button which is integral with the overload. In the latter case the s
used in the Schneider Electric TeSys enclosed motor starters, such as the TeSys LE range.

Remote and Emergency stops[2] are shown fitted between terminals A2 and 96, though they can also be fitted between 14 and 95, or even both involved.

**Warning**

Particular care must be taken to accurately fit the stop button when using the plunger type stop without any additional remote stop, as if for an disconnecting the supply.

**NOTES:**

**(1) These drawings are functional schematics. It remains the responsibility of the installer to ensure that the requirements of local dir protection is provided.**

**(2) Inclusion of E stops in these circuits is purely for illustrative purposes and may be acceptable in simple relatively low risk safety sy necessary, particularly in high risk applications. Consult you safety consultant.**

**NOTE regarding Terminal Numbering**

The circuits are based upon TeSys D range contactors and overloads. Terminal numbering is to a common standard so most other contactors c numbering systems.

**NOTE if using TeSys K**

The TeSys LR2K overloads (LR2K****) for use with TeSys K range contactors (LC1K****) have additional pins on their overloads to make such TeSys K systems unless the 2 right hand pins are first removed. These pins are specially weakened for this purpose and may easily be sn

**However, doing this is just making extra work. It is better to wire in accordance with the K Series diagram.**

Released for:Schneider Electric UK

**Attachment(s)**

K series DOL Wiring 3ph.pdf [260.91 KB]

Typical DOL start circuits.pdf [566.91 KB]

Published on:12/12/2011Last Modified on:07/11/2024

Did this answer your question?
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TeSys™ T LTMR Motor Management Controller – Installation Guide

English

· Hazard Categories and Special Symbols

o Please Note

· About the Book

· Introducing the TeSys T Motor Management System

· Installation

· Commissioning

· Maintenance

· Configurable Parameters

· Wiring Diagrams

· Glossary



DOCA0128EN-02

# Hazard Categories and Special Symbols

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service, or ma
clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety
are not followed.

This is the safety alert symbol. It is used to alert you to personal inju
or death.

**NOTE:** Provides additional information to clarify or simplify a procedure.

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## Document Scope

This guide describes the TeSys™ T LTMR motor management controller and LTME expansion module.

The purpose of this guide is to:

- Describe and explain the monitoring, protection, and control functions of the LTMR controller and LTME expansion module
- Provide all the information necessary to implement and support a solution that best meets your application requirements

The guide describes the four key parts of a successful system implementation:

- Installing the LTMR controller and LTME expansion module
- Commissioning the LTMR controller by setting essential parameter values
- Using the LTMR controller and LTME expansion module, both with and without additional human-machine interface devices
- Maintaining the LTMR controller and LTME expansion module

This guide is intended for:

- Design engineers
- System integrators

- System operators
- Maintenance engineers

## Validity Note

This guide is valid for all LTMR controllers. Some functions are available depending on the communication protocol and the software versio
controller.

## Related Documents

Expand Table

| Title of Documentation | Description | Reference Number |
|---|---|---|
| TeSys T LTMR - Motor Management Controller - User Guide | This is the main user guide that introduces the complete TeSys T range and describes the main functions of the TeSys T LTMR motor management controller and LTME expansion module. | DOCA0127EN |
| TeSys T LTMR - Motor Management Controller - Ethernet Communication Guide | This guide describes the Ethernet network protocol version of the TeSys T LTMR motor management controller. | DOCA0129EN |
| TeSys T LTMR - Motor Management Controller - Modbus Communication Guide | This guide describes the Modbus network protocol version of the TeSys T LTMR motor management controller. | DOCA0130EN |
| TeSys T LTMR - Motor Management Controller - PROFIBUS DP Communication Guide | This guide describes the PROFIBUS DP network protocol version of the TeSys T LTMR motor management controller. | DOCA0131EN |

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|---|---|---|---|
| TeSys T LTMR - Motor Management Controller - CANopen Communication Guide | This guide describes the CANopen network protocol version of the TeSys T LTMR motor management controller. | DOCA0132EN | |
| TeSys T LTMR - Motor Management Controller - DeviceNet Communication Guide | This guide describes the DeviceNet network protocol version of the TeSys T LTMR motor management controller. | DOCA0133EN | |
| TeSys® T LTM CU - Control Operator Unit - User Manual | This manual describes how to install, configure, and use the TeSys T LTMCU Control Operator Unit. | 1639581EN | |
| Compact Display Units - Magelis XBT N/XBT R - User Manual | This manual describes the characteristics and presentation of the XBT N/XBT R display units. | 1681029EN | |
| TeSys T LTMR Ethernet/IP with a Third-Party PLC - Quick Start Guide | This guide provides a single reference for configuring and connecting the TeSys T and the Allen-Bradley programmable logic controller (PLC). | DOCA0119EN | |
| TeSys T LTM R Modbus - Motor Management Controller - Quick Start Guide | This guide uses an application example to describe the different steps to quickly install, configure, and use TeSys T for Modbus network. | 1639572EN | |
| TeSys T LTM R Profibus-DP - Motor Management Controller - Quick Start Guide | This guide uses an application example to describe the different steps to quickly install, configure, and use TeSys T for PROFIBUS-DP network. | 1639573EN | |

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|---|---|---|---|
| TeSys T LTM R CANopen - Motor Management Controller - Quick Start Guide | This guide uses an application example to describe the different steps to quickly install, configure, and use TeSys T for CANopen network. | 1639574EN | |
| TeSys T LTM R DeviceNet - Motor Management Controller - Quick Start Guide | This guide uses an application example to describe the different steps to quickly install, configure, and use TeSys T for DeviceNet network. | 1639575EN | |
| Electromagnetic Compatibility - Practical Installation Guidelines | This guide provides an insight to the electromagnetic compatibility. | DEG999EN | |
| TeSys T LTM R•• - Instruction Sheet | This document describes the mounting and connection of the TeSys T LTMR motor management controller. | AAV7709901 | |
| TeSys T LTM E•• - Instruction Sheet | This document describes the mounting and connection of the TeSys T LTME expansion module. | AAV7950501 | |
| Magelis Compact Terminals XBT N/R/RT - Instruction Sheet | This document describes the mounting and connection of the Magelis XBT-N. | 1681014 | |
| TeSys T LTM CU• - Instruction Sheet | This document describes the mounting and connection of the TeSys T LTMCU control unit | AAV6665701 | |

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|---|---|---|
| TeSys T DTM for FDT Container - Online Help | This online help describes the TeSys T DTM and the custom logic editor embedded in the TeSys T DTM which allows the customization of the control functions of the TeSys T motor management system. | 1672614EN |
| TCSMCNAM3M002P USB to RS485 Converter - Quick Reference Guide | This instruction guide describes the configuration cable between computer and TeSys T: USB to RS485 | BBV28000 |
| Electrical Installation Guide (Wiki version) | The aim of the Electrical Installation Guide (and now Wiki) is to help electrical designers and contractors to design electrical installations according to standards such as the IEC60364 or other relevant standards. | www.electrical-installation.org |

You can download these technical publications and other technical information from our website at www.se.com.

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· lation
o General Principles
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o Wiring - Ground Current Sensors
o Wiring - Temperature Sensors
o Wiring - Power Supply
o Wiring - Logic Inputs
o Wiring - Logic Outputs
o Connecting to an HMI Device
· Commissioning
· Maintenance
· Configurable Parameters
· Wiring Diagrams
· Glossary
1. TeSys™ T LTMR Motor Management Controller – Installation Guide
2. Installation

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# Installation

## Overview

This chapter describes the physical installation and assembly of the LTMR controller and the LTME expansion module. It also explains how to c
enclosure or a switchboard.

**DANGER**

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Turn off all power supplying this equipment before working on it.

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices.

Failure to follow these instructions will result in death or serious injury.

**WARNING**

UNINTENDED EQUIPMENT OPERATION

- The application of this product requires expertise in the design and programming of control systems. Only persons with such expertise should be allo

- Follow all local and national safety codes and standards.

- Follow all electromagnetic compatibility rules described in this guide.

- Follow all installation and wiring rules described in this guide.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

WARNING: This product can expose you to chemicals including lead and lead compounds, which are known to the Sta

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## Functional Safety

### Introduction

The TeSys T motor management system is a part of a global architecture. To provide the functional safety, some risks must be analyzed such as:

- Global functional risks
- Risk of hardware and software breakdown
- Electromagnetic environmental risks.

To reduce the electromagnetic environment risks, installation rules and wiring must be respected.

For more information on EMC, refer to the *Electrical Installation Guide* chapter *ElectroMagnetic Compatibility (Wiki version available in Englis installation.org)*.

### Installation Rules

# Mounting

## Overview

This section describes how to mount the LTMR controller and the LTME expansion module on a DIN rail, a solid mounting plate, or a pre-sl
to remove each component.

Reminder: The LTMR controller and its LTME expansion module must be mounted side by side, with the LTME expansion module on the left side of the L

## Mounting on DIN Rails

You can mount the controller and the expansion module on a 35 mm (1.38 in.) DIN rail with a thickness of 1.35 mm (0.05 in.) and 0.75 mm (0.02 in.). Wh

| Step | Action |
|---|---|
| 1 | On the back of the controller are two DIN rail clips. Fit the top clip onto the DIN rail. |
| 2 | Push the controller in toward the DIN rail until the bottom clip catches. The controller clicks into place. |
| | |
| | |

## Removing from DIN Rails

To remove the controller from the DIN rail:

| Step | Action |
| --- | --- |
| 1 | Using a screwdriver, pull down the white locking mechanism to release the controller. |
| 2 | Lift the controller away from the DIN rail. |
| | |
| | |

## Mounting on a Solid Mounting Plate

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# Wiring - Generalities

## Overview

The wiring of each part of the LTMR controller and the LTME expansion module is detailed further with its specificities:

· Wiring the current transformers.

· Wiring the ground current sensors.

· Wiring the temperature sensors.

· Wiring the power supply.

· Wiring the logic inputs.

· Wiring the logic outputs.

- Wiring the voltage transformers on the LTME expansion module.

The wiring of the communication port depends on the communication protocol and is described in each communication guides.

## Wiring Rules

The following wiring rules must be respected in order to reduce disturbance due to EMC on the behavior of the LTMR controller:

- Keep a distance as large as possible between the communication cable and the power and/or control cables (minimum 30 cm or 11.8 in.).

- Cross over different types of cables at right angles, if necessary.
- Do not bend or damage the cables. The minimum bending radius is 10 times the cable diameter.
- Avoid sharp angles of paths or passage of the cable.
- Use shielded cables to connect ground current sensors:
  - The cable shield must be connected to a protective ground at both ends.
  - The connection of the cable shield to the protective ground must be as short as possible.
  - Connect together all the shields, if necessary.
  - Perform the grounding of the shield with a collar.
- Add filters on contactor coils for all contactors and relays.
- Place the cable along the grounded plate around the withdrawable drawer.

For more information, refer to the *Electrical Installation Guide* (available in English only), chapter *ElectroMagnetic Compatibility (EMC)*.

## Wiring Diagram Example: LTMR Controls a Three-phase Motor

The following diagram shows the wiring of the LTMR controller and its LTME expansion module used to control a three-phase motor in thre independent mode:

**A1, A2** LTMR controller power supply

**B1, B2** Power supply dedicated to logic outputs

## Wiring Diagram Example: LTMR Controls a Single-phase Motor

The following diagram shows the wiring of the LTMR controller and its LTME expansion module used to control a single-phase motor in thr independent mode:

**A1, A2** LTMR controller power supply

**B1, B2** Power supply dedicated to logic outputs

## LTMR Controller Plug-in Terminals and Pin Assignments

The LTMR controller has the following plug-in terminals and pin

assignments:

| Terminal Block | Pin | Description |
|---|---|---|
| Control voltage, logic input, and common source terminals | A1 | Supply voltage input (+ / ~) |
| | A2 | The negative of a power supply for DC models, or the grounded sec models (– / ~) |
| | I.1 | Logic input 1 |
| | I.2 | Logic input 2 |
| | I.3 | Logic input 3 |
| | I.4 | Logic input 4 |
| | I.5 | Logic input 5 |
| | I.6 | Logic input 6 |
| | C | Input common |
| O.4 Logic output terminals | 97–98 | NO contact |

| | | | |
|---|---|---|---|
| | 95–96 | NC contact | |
| | **Note:** The 97–98 contacts and the 95–96 contacts are on the same relay, so the open/closed status of one p pair. | | |
| O.1 to O.3 Logic output terminals | 13–14 | NO contact – logic output 1 | |
| | 23–24 | NO contact – logic output 2 | |
| | 33–34 | NO contact – logic output 3 | |

The LTMR controller has the following plug-in terminals and pin assignments for different communication protocols:

Expand Table

| Communication Protocol | Terminal Block | Pin | Descripti on |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Ethernet | Ground current trip input and temperature sensor input | Z1–Z2 | Connection for external grou |
| | | T1–T2 | Connection for motor tempe |
| PROFIBUS DP | Ground current trip input and temperature sensor input, and PLC terminals | Z1–Z2 | Connection for external grou |
| | | T1–T2 | Connection for embedded m elements |
| | | S | PROFIBUS DP shield or FE |

| | | | |
|---|---|---|---|
| | | A | Receive/transmit data-N |
| | | B | Receive/transmit data-P |
| | | DGND | Data ground pin |
| | | VP | Power supply pin) |
| CANopen | Ground current trip input, and temperature sensor input, and PLC terminals | Z1–Z2 | Connection for external |
| | | T1–T2 | Connection for embedde elements |
| | | V- | CANopen common pin |

| | | | |
|---|---|---|---|
| | | CAN.L | CAN.L pin (dominant low) |
| | | S | CANopen shield pin |
| | | CAN.H | CAN.H pin (dominant high) |
| | | V+ | CANopen external power su |
| DeviceNet | Ground current trip input and temperature sensor input, and PLC terminals | Z1–Z2 | Connection for external grou |
| | | T1–T2 | Connection for embedded m elements |
| | | V– | DeviceNet common pin |

| | | | |
|---|---|---|---|
| | | CAN.L | DeviceNet CAN.L pin ( low) |
| | | S | DeviceNet shield pin |
| | | CAN.H | DeviceNet CAN.H pin ( high) |
| | | V+ | DeviceNet external pow pin |

## LTME Expansion Module Plug-in Terminals and Pin Assignments

The LTME expansion module has the following plug-in terminals and pin assignments:

| **Terminal block** | **Pin** | **Description** | |
|---|---|---|---|
| Voltage inputs | LV1 | Phase 1 input voltage | |
| | LV2 | Phase 2 input voltage | |
| | LV3 | Phase 3 input voltage | |
| Logic inputs and common terminals | I.7 | Logic input 7 | |
| | C7 | Common for I.7 | |
| | I.8 | Logic input I.8 | |
| | C8 | Common for I.8 | |
| | I.9 | Logic input I.9 | |
| | C9 | Common for I.9 | |

| | | | |
|---|---|---|---|
| | I.10 | Logic input I.10 | |
| | C10 | Common for I.10 | |

## Terminal Wiring Characteristics

Both the LTMR controller and LTME expansion module terminals have the same characteristics.

Terminals have an insulation rating of 320 Vac.

The following table describes the characteristics of cables that may be used to wire the terminals:

| **Cable Type** | **No. of Conductors** | **Conductor Section** | |
|---|---|---|---|
| | | **mm²** | **AWG** |
| Flexible (stranded) cable | Single conductor | 0.2...2.5 | 24...14 |
| | Two conductors | 0.2...1.5 | 24...16 |
| Solid cable | Single conductor | 0.2...2.5 | 24...14 |
| | Two conductors | 0.2...1.0 | 24...18 |
| Flexible (stranded) cable with insulated cable ends | Single conductor | 0.25...2.5 | 24...14 |
| | Two conductors | 0.5...1.5 | 20...16 |
| Flexible (stranded) cable with non-insulated cable ends | Single conductor | 0.25...2.5 | 24...14 |

| | | | |
|---|---|---|---|
| | Two conductors | 0.2...1.0 | 24...18 |

The following table describes the characteristics of the terminals:

| | | |
|---|---|---|
| **Pitch** | 5.08 mm | 0.2 in. |
| **Tightening torque** | 0.5 to 0.6 N•m | 5 lb-in |
| **Flat screwdriver** | 3 mm | 0.10 in. |

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Was this helpful?

You can mount the controller and the expansion module on a metal mounting plate using ST2.9 steel tapping screws: four for the controller and two for dimensions by 8 mm (0.3 in.) in both directions. To mount the controller and the expansion module on a mounting plate:

| Step | Action |
|---|---|
| 1 | Locate the four mounting holes at each corner of the controller and the two mounting holes on the expansion module. |
| 2 | Position the controller and expansion module on the mounting plate, making sure to leave enough space for the c |

| | | |
|---|---|---|
| 3 | Insert each of the six tapping screws. | |
| 4 | Use a screwdriver to tighten each screw and secure the controller and the expansion module in place. Torque N•m (8.8 lb-in). | |

## Mounting on a TE Plate

You can mount the controller and the expansion module on a TE plate, such as Telequick, using six mounting clips (AF1 EA4). When mounted, the controller Telequick:

| Step | Action |
|---|---|

| | |
|---|---|
| 1 | Attach the six mounting clips to Telequick, as shown in the diagram below. The rounded edge should face<br>bottom clips. |
| 2 | Position the controller and expansion module on the clips so that the holes in the clips and the holes in the<br>turn them slightly. |

| | |
|---|---|
| 3 | When the controller and expansion module are properly positioned, tighten first the bottom screws, then the to N•m (8.8 lb-in). |

## Operating Position

You can mount the controller and the expansion module at an angle of up to 90 degrees perpendicular to the normal vertical mounting plane.

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Was this helpful?

Installation rules that must be respected to enable the LTMR to operate correctly include:

- Installation rules for the components:
  - Association of the LTMR controller with the LTME expansion module.
  - Installation in a switchboard such as Okken, Blokset, or another type.

· LTMR controller wiring rules:

  - Wiring of the power supply
  - Wiring of the I/Os: logic input wiring and logic output wiring
- Communication network wiring rules.

## Installation Rules in a Switchboard

The installation of the LTMR controller in the withdrawable drawer of a switchboard presents constraints specific to the type of switchboard:

- For installation of the LTMR controller in a Schneider Electric Okken switchboard, refer to the *Okken Communications Cabling & Wiring Gu* (available on request).

- For installation of the LTMR controller in a Schneider Electric Blokset switchboard, refer to the *Blokset Communications Cabling & Wiri* (available on request).
- For installation of the LTMR controller in other types of switchboard, follow the specific EMC instructions described in this guide and ref of switch
- DOCA0128EN-02

## Dimensions

### Overview

- This section presents the dimensions of the LTMR controller and the LTME expansion module, as well as the dimensions of the clearance LTMR and LTME models.

### LTMR Controller Dimensions

-

**NOTE:** The height of the controller may increase when using alternate wiring terminals.

### LTME Expansion Module Dimensions

-

### Clearance Zone Dimensions

- For EMC (Electromagnetic Compatibility), it is recommended to mount a contactor at a distance of more than 5 cm (1.97 in) from the LTM expansion module.
- The maximum rated ambient temperature of the controller depends on the clearance zone dimensions. They are shown in the following table.
-


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# Wiring - Power Supply

## Overview

The LTMR controller supply voltage can be:

- 24 Vdc, or
- 100…240 Vac

The following table presents LTMR controller and LTME expansion module association rules:

| | **LTMR•••BD (VDC)** | **LTMR•••FM (VAC)** |
|---|---|---|
| **LTME••BD (VDC)** | X | X |
| **LTME••FM (VAC)** | – | X |
| **X** Association allowed | | |
| **–** Association not allowed | | |

## DC Power Supply

A dedicated 24 Vdc power supply is necessary to supply:

- One or several LTMR controllers including the logic inputs of the LTMR controller(s).
- The logic inputs of the LTME expansion module(s).

An additional specific 24 Vdc power supply is necessary to supply:

- The LTMR controller logic outputs.
- Other devices.

The LTMR controller DC power supply must have the following characteristics:

- AC/DC converter.
- Galvanic isolation input AC / output DC: 4 kVac minimum at 50 Hz.
- Input voltage: 240 Vac (+15% / -20%).

- Output voltage: 24 Vdc (+/-10%).

The following Schneider Electric ABL8RPS24••• power supplies are recommended:

| Reference Number | Input Voltage | Output Voltage/Current | Maximum Number of I Supplied |
|---|---|---|---|
| ABL8RPS24100 | 200…500 Vac | 24 Vdc / 10 A | 24 |
| ABL8RPS24050 | 200…500 Vac | 24 Vdc / 5 A | 12 |
| ABL8RPS24030 | 200…500 Vac | 24 Vdc / 3 A | 8 |

## AC Power Supply

A dedicated AC/AC power supply or UPS is necessary to supply:

- One or several LTMR controllers including the logic inputs of the LTMR controller(s).
- The logic inputs of the LTME expansion module(s).

An additional specific AC or DC power supply is necessary to supply:

- The LTMR controller logic outputs.
- Other devices.

The LTMR controller AC power supply or UPS must have the following characteristics:

- Isolation transformer
- Output voltage: 115 or 230 Vac (+15% / -20%)
  - 115 Vac output voltage is recommended.
  - With 230 Vac output voltage, an additional LTM9F external filter may be necessary.
- Power according to the number of LTMR controllers (several AC supplies are recommended).
- UPS is mandatory if voltage is unstable and does not follow EN 50160.

## Power Supply Daisy Chaining

When the same power supply (AC or DC) is used to supply several LTMR controllers, it is recommended to close the loop:

- To avoid power off,
- To reduce voltage drop due to long cables.

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# Wiring - Logic Inputs

## Overview

10 logic inputs maximum are provided:

- Six logic inputs on the LTMR controller, internally powered by the LTMR.
- Four logic inputs on the LTME expansion module, independently powered.

## Logic Inputs of the LTMR Controller

The controller LTMR has six logic inputs:

- Available via field wiring terminals I.1- I.6.
- Internally powered by the control voltage of the LTMR controller (the input voltage is the same voltage as the controller supply voltage.)
- Isolated from the inputs of the LTME expansion module.

The three Common (C) terminals of the LTMR controller are connected to the A1 control voltage via an internal filter, as shown in the wiring diagram examp

**NOTICE**

LOGIC INPUTS DESTRUCTION HAZARD

- Connect the LTMR controller's inputs using the three Common (C) terminals connected to the A1 control voltage via an internal filter.
- Do not connect the Common (C) terminal to the A1 or A2 control voltage inputs.

Failure to follow these instructions can result in equipment damage.

For more information, refer to the power supply wiring and the technical specifications of the LTMR controller in the TeSys T LTMR Motor Management

## Logic Inputs of the LTME Expansion Module

The four logic inputs on the LTME expansion module (I.7 - I.10) are not powered by the control voltage of the LTMR controller.

For more information, refer to the technical specifications of the LTME expansion module in the TeSys T LTMR Motor Management Controller User Guid

## Controller AC Inputs Setting

The LTMR controller uses digital filters to obtain a correct AC signal on the inputs.

For more accurate results, this filter can be configured by the controller AC inputs setting register to set the voltage supply and activate the ad feature.

## Connection of the Logic Inputs

**NOTICE**

UNINTENDED EQUIPMENT OPERATION

- Install interposing relay for long distance inputs.
- Segregate control cable from power cable.
- Use dry contact on LTMR inputs.
- Respect the recommendations given in this chapter.

Failure to follow these instructions can result in unwanted motor stops.

Three types of connection are possible:

- Direct connection for all information on logic inputs coming from the switchboard.
- Connection via interposing relays for all information on logic inputs coming from outside of the switchboard and mainly connected with long lines.

Using interposing relays reduces EMC disturbance effects on the LTMR controller and improves the reliability of the information.

- Connection without interposing relays for logic input on short distance.

For TeSys T inputs / outputs applications, only dry contacts free of potential can be used. Otherwise, current could be supplied to sensor or devic / output state.

## Inductive Interference

For parallel cable runs above 100 m (328 ft) with close proximity between control and power, an induced voltage can be generated and cause the in AC, it is possible to add a clamping resistor in parallel of the interposing relay.

## Maximum Distance Without Interposing Relay

The maximum distance allowed without interposing relay is addressed below:

| **Wire Size** | 1 $mm^2$ (AWG 18) | 1.5 $mm^2$ (AWG 16) | 2 $mm^2$ (AWG 14) | 2.5 $mm^2$ (A |
|---|---|---|---|---|
| **Maximum distance for wires** | 210 m (689 ft) | 182 m (597 ft) | 163 m (535 ft) | 149 m (489 ft) |

However, due to variability of installations it is highly recommended to use interposing relays for control cable lengths longer than 100 m (328 ft).

## Recommended Interposing Relay

Interposing relays must have the following characteristics:

- Electromechanical relay with 2.5 kVac isolation minimum.
- Self-cleaning or low level contact (I < 5 mA).
- Installed in the switchboard as close as possible to the LTMR controller.
- AC or DC control circuit voltage, supplied by separate power supply (not supplied by the same power supply as the LTMR controller to re galvanic isolation).

In case of long distances between the process and the LTMR controller, interposing relays with DC control circuit voltage are recommended.

The protection module is mandatory on the interposing relays in order to suppress the surge.

The following Schneider Electric RSB1 interposing relays are recommended:

| **Reference Number** | **Control Circuit Voltage** | **Protection Module** |
|---|---|---|
| RSB1A120•D | 6, 12, 24, 48, 60, 110 Vdc | Diode RZM040W |
| RSB1A120•7 | 24, 48 Vac | RC circuit RZM041BN7 |
| RSB1A120•7 | 120, 220, 230, 240 Vac | RC circuit RZM041FU7 |

## Use of DC Interposing Relays

The DC interposing relays are recommended because long wires distances can be used to command the relay.

| DC RSB1 relay voltage | 24 Vdc | 48 Vdc | 110 Vdc |
|---|---|---|---|
| **Maximum distance for wires in parallel without metallic screening** | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) |
| **Maximum distance for wires in parallel with metallic screening** | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) |

The following diagram shows an example when using DC interposing relays:

## Use of AC Interposing Relays

The use of an AC interposing relay is allowed only on short distances if an AC voltage is mandatory.

| AC RSB1 relay voltage | 24 Vac | 48 Vac | 120 Vac | 230/240 Vac |
|---|---|---|---|---|
| **Maximum distance for wires in parallel without metallic screening** | 3,000 m (10,000 ft) | 1,650 m (5,500 ft) | 170 m (550 ft) | 50 m (165 ft) |
| **Maximum distance for wires in parallel with metallic screening** | 2,620 m (8,600 ft) | 930 m (3,000 ft) | 96 m (315 ft) | 30 m (100 ft) |

The following diagram shows an example when using AC interposing relays:

## Use of AC Interposing Relays with a Rectifier

The use of AC interposing relay with a rectifier is recommended on long distances if an AC voltage is mandatory.

Add a rectifier composed of 1 A / 1,000 V diodes to command an AC interposing relay. In this way, rectified AC current flows in the control continuous part is closed.

Relay drop out time increases with the stray capacitance (long cable length) because the capacitance reduces the inductive behavior of the coi phenomenon is important.

| **AC RSB1 relay voltage** | 24 Vac | 48 Vac | 120 Vac | 230/240 Vac |
|---|---|---|---|---|
| **Maximum distance for wires in parallel without metallic screening** | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (1( |
| **Maximum distance for wires in parallel with metallic screening** | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (10,000 ft) | 3,000 m (1( |

The following diagram shows an example when using AC interposing relays with a rectifier:

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# Wiring - Logic Outputs

## Overview

The four logic outputs of the LTMR controller are relay outputs. The relay outputs command the motor managed by the LTMR controller.

The four relay outputs on the LTMR controller are:

- Three single pole / single throw (SPST, NO) relay outputs
- One double pole / single throw (DPST, NC+NO) relay output

## Output Interposing Relays

When an output commands a contactor, an interposing relay may be required depending of the coil voltage and the power required by the contact

The following diagrams illustrate system wiring without and with the use of an interposing relay KA1:

**B1, B2** Power supply dedicated to logic outputs

The LTMR controller logic output characteristics are:

- Rated insulation voltage: 300 V
- AC rated thermal load: 250 Vac / 5 A
- DC rated thermal load: 30 Vdc / 5 A
- AC 15 rating: 480 VA, 500,000 operations, Ie max = 2 A
- DC 13 rating: 30 W, 500,000 operations, Ie max = 1.25 A

If the LTMR controller logic output is not able to control directly the contactor, an interposing relay is required.

The protection module is mandatory on the interposing relays in order to suppress the surge.

## Recommended Contactors

The tables in the appendix, listing the references and characteristics of Schneider Electric contactors, specify whether an interposing relay is requ
*Guide*. DOCA0128EN-02

# Connecting to an HMI Device

## Overview

This section describes how to connect the LTMR controller to an HMI device, such as a Magelis XBT or a TeSys T LTMCU, or to a PC running
on the LTME expansion module.

The Magelis XBT HMI device must be powered separately. Connect it to a controller in one-to-many mode.

## Wiring Rules

The wiring rules must be respected in order to reduce disturbance on the behavior of the LTMR controller due to EMC.

The exhaustive list of wiring rules is described in the general recommendations.

**NOTICE**

UNINTENDED EQUIPMENT OPERATION

Use Schneider Electric standard cables.

Failure to follow these instructions can result in equipment damage.

## Connecting to a Magelis XBT HMI Device in One-to-Many Mode

The diagram below shows a one-to-many connection from the Magelis XBTN410 HMI to up to eight controllers, with and without the LTME module:

**1** Magelis XBTN410 HMI device

**2** Magelis connecting cable XBTZ938

**3** T-junction boxes VW3 A8 306 TF••

**4** Shielded cable with two RJ45 connectors VW3 A8 306 R••

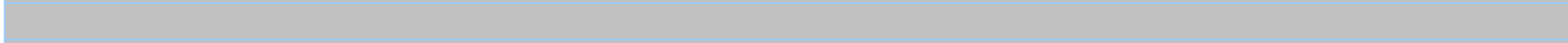
**5** Line terminator VW3 A8 306 R

**6** LTMR controller

**7** LTME expansion module

## Connecting to a TeSys T LTMCU HMI Device

The diagrams below show the TeSys T LTMCU HMI device connected to the LTMR controller, without and with the LTME expansion module:

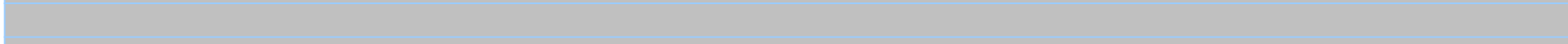


**1** LTMCU Control Operator Unit
**2** Grounding collar
**3** LTM9CU•• HMI device connection cable
**4** LTMR controller
**5** LTME expansion module

## Connecting to a Generic HMI Device

Connect the LTMR controller and the expansion module to an HMI device of your choice, using a shielded cable for Modbus bus, reference TSX CSA •••.

The RJ45 port pinouts to connect to the HMI port of the LTMR controller or the LTME expansion module is:



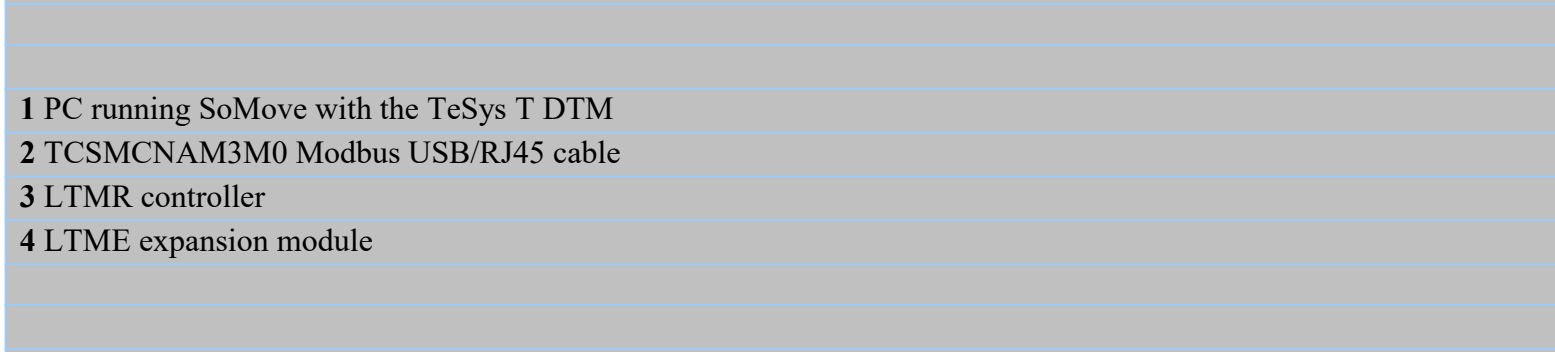
The RJ45 wiring layout is:

| Pin No. | Signal | Description |
|---|---|---|
| 1 | Reserved | Do not connect |
| 2 | Reserved | Do not connect |
| 3 | – | Not connected |
| 4 | D1 or D(B) | Communication between HMI and LTMR controller |
| 5 | D0 or D(A) | Communication between HMI and LTMR controller |
| 6 | Reserved | Do not connect |

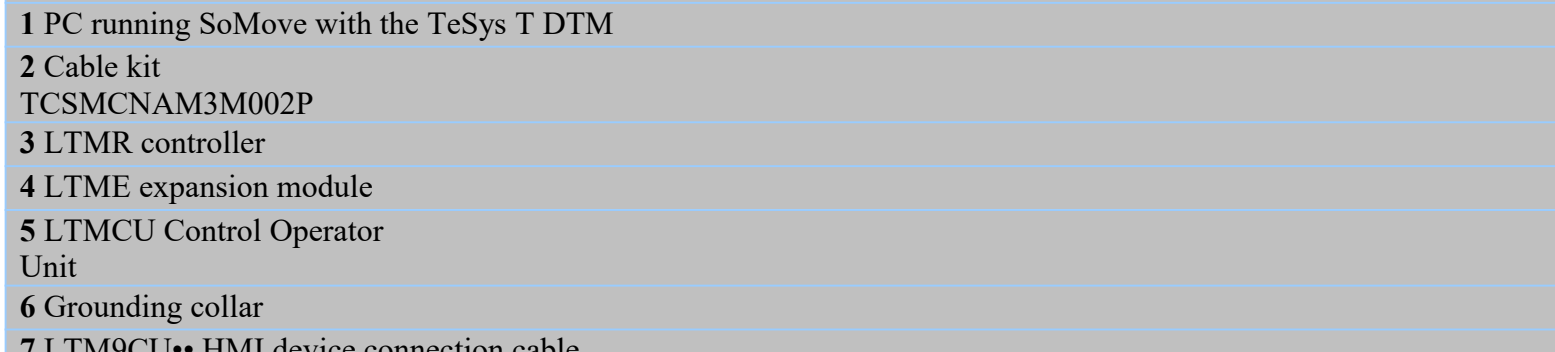
| | | |
|---|---|---|
| 7 | VP | +7 Vdc (100 mA) power supply provided by the LTMR controller |
| 8 | Common | Signal and power supply common |

## Connecting to a PC Running SoMove with the TeSys T DTM in One-to-One Mode Using the HMI Port

The diagrams below show a one-to-one connection from a PC running SoMove with the TeSys T DTM to the HMI port of the LTMR control and the LTMCU:



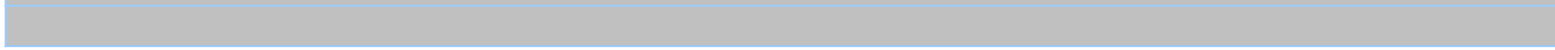
**1** PC running SoMove with the TeSys T DTM
**2** TCSMCNAM3M0 Modbus USB/RJ45 cable
**3** LTMR controller
**4** LTME expansion module



**1** PC running SoMove with the TeSys T DTM
**2** Cable kit TCSMCNAM3M002P
**3** LTMR controller
**4** LTME expansion module
**5** LTMCU Control Operator Unit
**6** Grounding collar
**7** LTM9CU•• HMI device connection cable

## Connecting to a PC Running SoMove with the TeSys T DTM in One-to-One Mode Using One LTMR Ethernet Network Port

The diagrams below show a one-to-one connection from a PC running SoMove with the TeSys T DTM to one of the two network ports of the and the LTMCU:



| |
|---|
| **1** PC running SoMove with the TeSys T DTM |
| **2** Cat 5 shielded or unshielded twisted pair Ethernet cable |
| **3** LTMR Ethernet controller |
| **4** LTME expansion module |
| |
| |
| **1** PC running SoMove with the TeSys T DTM |
| **2** Cat 5 shielded or unshielded twisted pair Ethernet cable |
| **3** LTMR Ethernet controller |
| **4** LTME expansion module |
| **5** LTMCU Control Operator Unit |
| **6** Grounding collar |
| **7** LTM9CU•• HMI device connection cable |
| When the LTMCU is connected to a PC, the LTMCU becomes passive and cannot be used to visualize information. |
| **Connecting to a PC Running SoMove with the TeSys T DTM in One-to-Many Mode** |
| The diagram below shows a one-to-many connection from a PC running SoMove with the TeSys T DTM to up to eight controllers (with or witho expansion module): |
| |
| |
| **1** PC running SoMove with the TeSys T DTM |
| **2** Cable kit TCSMCNAM3M002P |
| **3** T-junction boxes VW3 A8 306 TF••, including a shielded cable with two RJ45 connectors |
| **4** Shielded cable with 2 RJ45 connectors VW3 A8 306 R•• |
| **5** Line terminator VW3 A8 306 R |

**6** LTMR controller

**7** LTME expansion module

**NOTE:** For Modbus communication protocol, this connection requires to define different HMI communication addresses. The factory setting is 1.

## Connection Accessories

The following table lists connection accessories for the Magelis XBT and other HMI devices:

| Designation | Description | Reference |
|---|---|---|
| T-junction boxes | Box with two RJ45 socket connectors for trunk cable and an integrated 0.3 m (1 ft) cable with one RJ45 plug connector for tap-off | VW3 A8 306 TF03 |
| | Box with two RJ45 socket connectors for trunk cable and an integrated 1 m (3.2 ft) cable with one RJ45 plug connector for tap-off | VW3 A8 306 TF10 |
| Line terminator for RJ45 connector | R = 120 Ω | VW3 A8 306 R |
| Magelis connecting cable | Length = 2.5 m (8.2 ft) | XBTZ938 |
| (Magelis XBTN410 only) | 25 pts SUB-D connector to connect to Magelis® XBT | |
| Cable kit | Length = 2.5 m (8.2 ft) | TCSMCNAM3M002P |
| | USB to RS 485 converter | |
| Communication cables | Length = 0.3 m (1 ft) | VW3 A8 306 R03 |
| | Length = 1 m (3.2 ft) | VW3 A8 306 R10 |
| | Length = 3 m (3.2 ft) | VW3 A8 306 R30 |
| HMI device connection cable | Length = 1 m (3.2 ft) | LTM9CU10 |

| | | |
|---|---|---|
| | Length = 3 m (9.6 ft) | LTM9CU30 |

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1. TeSys™ T LTMR Motor Management Controller – Installation Guide

2. Configurable Parameters

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# Configurable Parameters

## Overview

The configurable parameters for the LTMR controller and the LTME expansion module are described below. The sequence of parameter configu
with the TeSys T DTM.

Parameters are grouped according to the TeSys T DTM parameter list tab. To help you find the link with the variable tables in the Use chapter, ea
number attached.

**WARNING**

RISK OF UNINTENDED CONFIGURATION AND OPERATION

When modifying parameter settings of the LTMR controller:

- Be especially careful if you change parameter settings when the motor is running.

- Disable network control of the LTMR controller to prevent unintended parameter configuration and operation.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

## Phases

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Motor phases | • Three-phase motor | Three-phase motor |
| | • Single-phase motor | |

## Operating Mode

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Motor operating mode | • Overload 2-wire | Independent 3-wire |
| | • Overload 3-wire | |
| | • Independent 2-wire | |
| | • Independent 3-wire | |
| | • Reverser 2-wire | |
| | • Reverser 3-wire | |
| | • Two-step 2-wire | |

| | | |
|---|---|---|
| | • Two-step 3-wire | |
| | • Two-speed 2-wire | |
| | • Two-speed 3-wire | |
| | • Custom | |
| Motor star-delta | 0 = disabled | 0 |
| | 1 = enabled | |

## Contactor

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Contactor rating | 1...1,000 A in increments of 0.1 A | 810 A |

## Motor

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Motor nominal voltage | 110…690 V | 400 V |
| Motor nominal power | 0.134...1339.866 HP | 10.05 HP |
| Motor nominal power | 0.1...999.9 kW in increments of 0.1 kW | 7.5 kW |
| Motor auxiliary fan cooled | • Disable | Disable |
| | • Enable | |
| Motor full load current ratio (FLC1) | 5...100 % FLCmax in increments of 1 % | 5 % FLCmax |
| Motor full load current | – | – |
| Motor high speed full load current ratio (FLC2) | 5...100 % FLCmax in increments of 1 % | 5 % FLCmax |
| Motor high speed full load current (FLC2) | 0...100 A in increments of 1 A | 5:00 AM |

## Load Current Transformer

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Load CT primary | 1...65,535 in increments of 1 | 1 |

| | | | |
|---|---|---|---|
| Load CT secondary | 1...500 in increments of 1 | 1 | |
| Load CT multiple passes | 1...100 passes in increments of 1 | 1 | |

**Ground Current Sensor**

| Parameter | Setting Range | Factory Setting | |
|---|---|---|---|
| Ground current mode | • Internal | Internal | |
| | • External | | |
| Ground CT primary | 1...65,535 in increments of 1 | 1 | |
| Ground CT secondary | 1...65,535 in incr | | |

# Control

**Operating Mode**

| Parameter | Setting Range | Factory Setting | |
|---|---|---|---|
| Control direct transition | On / Off | Off | |
| Motor transition timeout | 0...999.9 s | 1 s | |
| Motor Step 1 to 2 threshold | 20...800 % FLC in increments of 1 % | 150 % FLC | |
| Motor Step 1 to 2 timeout | 0.1...999.9 s | 5 s | |

**Inputs/Outputs**

| Parameter | Setting Range | Factory Setting | |
|---|---|---|---|
| Controller AC logic inputs configuration | • Unknown | Unknown | |
| | • Lower than 170V 50Hz | | |
| | • Lower than 170V 60Hz | | |
| | • Greater than 170V 50Hz | | |
| | • Greater than 170V 60Hz | | |
| Logic input 3 external ready enable | • Disable | Disable | |

| | | |
|---|---|---|
| | • Enable | |

## Rapid Cycle

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Rapid cycle lockout timeout | 0...9999 s in increments of 1 s | 0 s |

## Local/Remote Control

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Control remote channel setting | • Network | Network |
| | • Terminal strip | |
| | • HMI | |
| Control local channel setting | • Terminal strip | Terminal strip |
| | • HMI | |
| Control transfer mode | • Bump | Bump |
| | • Bumpless | |
| Control remote local buttons enable | • Disable | Disable |
| | • Enable | |
| Control remote local default mode | • Remote | Remote |
| | • Local | |
| Stop HMI disable | • Enable | Disable |
| | • Disable | |
| Stop terminal strip disable | • Enable | Disable |
| | • Disable | |

## Diagnostic

| Parameter | Setting Range | Factory Setting |
|---|---|---|

| | | |
|---|---|---|
| Diagnostic trip enable | • Disable | Enable |
| | • Enable | |
| Diagnostic alarm enable | • Disable | Enable |
| | • Enable | |
| Wiring trip enable | • Disable | Enable |
| | • Enable | |
| Motor phases sequence | • A B C | A B C |
| | • A C B | |

**Trip and Alarm**

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Trip reset mode | • Manual or HMI | Manual or HMI |
| | • Remote by network | |
| | • Automatic | |
| Auto-reset attempts group 1 setting | 0 = manual, 1, 2, 3, 4, 5 = unlimited number of reset attempts | 5 |
| Auto-reset group 1 timeout | 0...9,999 s in increments of 1 s | 480 s |
| Auto-reset attempts group 2 setting | 0 = manual, 1, 2, 3, 4, 5 = unlimited number of reset attempts | 0 |
| Auto-reset group 2 timeout | 0...9999 s in increments of 1 s | 1,200 s |
| Auto-reset attempts group 3 setting | 0 = manual, 1, 2, 3, 4, 5 = unlimited number of reset attempts | 0 |
| Auto-reset group 3 timeout | 0...9999 s in increments of 1 s | 60 s |

## Communication

### Network Port Control and Fallback Configuration

For information about the configuration parameters of the communication network, refer to

- *TeSys T LTMR Ethernet Communication Guide*

- *TeSys T LTMR Modbus Communication Guide*
- *TeSys T LTMR PROFIBUS DP Communication Guide*
- *TeSys T LTMR CANopen Communication Guide*
- *TeSys T LTMR DeviceNet Communication Guide*

## HMI Port

Expand Table

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| HMI port address setting | 1...247 | 1 |
| HMI port baud rate setting | • 4800 | 19,200 bits/s |
| | • 9600 | |
| | • 19,200 | |
| | • Self detection | |
| HMI port parity setting | • None | Even |
| | • Even | |
| HMI port endian setting | • LSW first (little endian) | MSW first (big endian) |
| | • MSW first (big endian) | |
| HMI port fallback setting | • Hold LO1 LO2 | LO1, LO2 off |
| | • Run (2-step) or off | |
| | • LO1, LO2 off | |
| | • LO1, LO2 on (ovl, ind, cust) or off | |
| | • LO1 on or off (2-step) | |
| | • LO2 on or off (2-step) | |
| HMI port trip enable | • Disable | Disable |
| | • Enable | |
| HMI port alarm enable | • Disable | Disable |

| | | |
|---|---|---|
| | • Enable | |
| Config via HMI engineering tool enable | • Forbidden | Allowed |
| | • Allowed | |
| Config via HMI keypad enable | • Forbidden | Allowed |
| | • Allowed | |

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## Thermal

### Thermal Overload

Expand Table

| Parameter | Setting Range | Factory Setting |
|---|---|---|
| Thermal overload mode | • Definite | Inverse thermal |
| | • Inverse thermal | |
| Motor trip class | • Motor class 5 | Motor class 5 |
| | • Motor class 10 | |
| | • Motor class 15 | |
| | • Motor class 20 | |
| | • Motor class 25 | |
| | • Motor class 30 | |
| Thermal overload trip enable | • Disable | Enable |
| | • Enable | |
| Thermal overload trip reset threshold | 35...95 % in increments of 1 % | 75% |

| | | |
|---|---|---|
| Thermal overload alarm enable | • Disable | Enable |
| | • Enable | |
| Thermal overload alarm threshold | 10...100 % in increments of 1 % | 85% |
| Long start trip timeout | 1...200 s in increments of 1 s | 10 s |
| Thermal overload trip enable | • Disable | Enable |
| | • Enable | |
| Thermal overload trip definite timeout | 1...300 s in increments of 1 s | 10 s |
| Thermal overload alarm enable | • Disable | Enable |
| | • Enable | |

## Motor Temperature

| **Parameters** | **Setting range** | **Factory setting** |
|---|---|---|
| Motor temperature sensor type | • None | None |
| | • PTC binary | |
| | • PT100 | |
| | • PTC analog | |
| | • NTC analog | |
| Motor temperature sensor trip enable | • Disable | Disable |
| | • Enable | |
| Motor temperature sensor trip threshold | 20...6,500 Ω | 20 Ω |

| | | | |
|---|---|---|---|
| Motor temperature sensor trip threshold degree | 0...200 °C | 0 °C | |
| Motor temperature sensor alarm enable | • Disable | Disable | |
| | • Enable | | |
| Motor temperature sensor alarm threshold | 20...6,500 Ω | 20 Ω | |
| Motor temperature sensor alarm threshold degree | 0...200 °C | 0 °C | |

## urrent

### Ground Current

| **Parameters** | **Setting range** | **Factory setting** | |
|---|---|---|---|
| Ground current disable while motor starting | • No | No | |
| | • Yes | | |
| Ground current trip enable | • Disable | Enable | |
| | • Enable | | |
| Internal ground current trip threshold | 20...500 % FLCmin in increments of 1 % | 30 % FLCmin | |
| Internal ground current trip timeout | 0.5...25 s in increments of 0.1 s | 1 s | |
| External ground current trip threshold | 0.02...20 A in increments of 0.01 A | 1:00 AM | |
| External ground current trip timeout | 0.1...25 s in increments of 0.01 s | 0.5 s | |
| Ground Current alarm enable | • Disable | Enable | |
| | • Enable | | |

| | | |
|---|---|---|
| Internal ground current alarm threshold | 50...500 % FLCmin in increments of 1 % | 50 % FLCmin |
| External ground current alarm threshold | 0.02...20 A in increments of 0.01 A | 1:00 AM |

## Phases

| Parameters | Setting range | Factory setting |
|---|---|---|
| Current phase imbalance trip enable | • Disable | Enable |
| | • Enable | |
| Current phase imbalance trip threshold | 10...70 % in increments of 1 % | 10% |
| Current phase imbalance trip timeout starting | 0.2...20 s in increments of 0.1 s | 0.7 s |
| Current phase imbalance trip timeout running | 0.2...20 s in increments of 0.1 s | 5 s |
| Current phase imbalance alarm enable | • Disable | Disable |
| | • Enable | |
| Current phase imbalance alarm threshold | 10...70 % in increments of 1 % | 10% |
| Current phase loss trip enable | • Disable | Enable |
| | • Enable | |
| Current phase loss timeout | 0.1...30 s in increments of 0.1 s | 3 s |
| Current phase loss alarm enable | • Disable | Enable |
| | • Enable | |

| | | |
|---|---|---|
| Current phase reversal trip enable | • Disable | Disable |
| | • Enable | |

### Long Start

| Parameters | Setting range | Factory setting |
|---|---|---|
| Long start trip enable | • Disable | Enable |
| | • Enable | |
| Long start trip threshold | 100...800 % FLC in increments of 1 % | 100 % FLC |
| Long start trip timeout | 1...200 s in increments of 1 s | 10 s |

### Jam

| Parameters | Setting range | Factory setting |
|---|---|---|
| Jam trip enable | • Disable | Enable |
| | • Enable | |
| Jam trip threshold | 100...800 % FLC in increments of 1 % | 200 % FLC |
| Jam trip timeout | 1...30 s in increments of 1 s | 5 s |
| Jam alarm enable | • Disable | Disable |
| | • Enable | |
| Jam alarm threshold | 100...800 % FLC in increments of 1 % | 200 % FLC |

### Undercurrent

| Parameters | Setting range | Factory setting |
|---|---|---|
| Undercurrent Trip Enable | • Disable | Disable |
| | • Enable | |
| Undercurrent Trip Threshold | 30...100 % FLC in increments of 1 % | 50 % FLC |
| Undercurrent Trip Timeout | 1...200 s in increments of 1 s | 10 s |
| Undercurrent Alarm Enable | • Disable | Disable |
| | • Enable | |

| | | |
|---|---|---|
| Undercurrent Alarm Threshold | 30...100 % FLC in increments of 1 % | 50 % FLC |

## Overcurrent

| Parameters | Setting range | Factory setting |
|---|---|---|
| Overcurrent trip enable | • Disable | Disable |
| | • Enable | |
| Overcurrent Trip Threshold | 20...800 % FLC in increments of 1 % | 200 % FLC |
| Overcurrent trip timeout | 1...250 s in increments of 1 s | 10 s |
| Overcurrent alarm enable | • Disable | Disable |
| | • Enable | |
| Overcurrent alarm threshold | 20...800 % FLC in increments of 1 % | 200 % FLC |

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# Voltage

### Phases

| Parameters | Setting range | Factory setting |
|---|---|---|

| | | |
|---|---|---|
| Voltage phase imbalance trip enable | • Disable | Disable |
| | • Enable | |
| Voltage phase imbalance trip threshold | 3...15 % of the calculated imbalance in increments of 1 % | 10 % imbalance |
| Voltage phase imbalance trip timeout starting | 0.2...20 s in increments of 1 s | 0.7 s |
| Voltage phase imbalance trip timeout running | 0.2...20 s in increments of 1 s | 2 s |
| Voltage phase imbalance alarm enable | • Disable | Disable |
| | • Enable | |
| Voltage phase imbalance alarm threshold | 3...15 % of the calculated imbalance in increments of 1 % | 10 % imbalance |
| Voltage phase loss trip enable | • Disable | Disable |
| | • Enable | |
| Voltage phase loss trip timeout | 0.1...30 s in increments of 0.1 s | 3 s |
| Voltage phase loss alarm enable | • Disable | Disable |
| | • Enable | |
| Voltage phase reversal trip enable | • Disable | Disable |
| | • Enable | |

**Undervoltage**

| **Parameters** | **Setting range** | **Factory setting** |
|---|---|---|

| | | |
|---|---|---|
| Undervoltage trip enable | • Disable | Disable |
| | • Enable | |
| Undervoltage trip threshold | 70...99 % of Motor nominal voltage in increments of 1 % | 85 % of Motor nominal voltage |
| Undervoltage trip timeout | 0.2...25 s in increments of 0.1 s | 3 s |
| Undervoltage alarm enable | • Disable | Disable |
| | • Enable | |
| Undervoltage alarm threshold | 70...99 % of Motor nominal voltage in increments of 1 % | 85 % of Motor nominal voltage |

## Overvoltage

| Parameters | Setting range | Factory setting |
|---|---|---|
| Overvoltage trip enable | • Disable | Disable |
| | • Enable | |
| Overvoltage trip threshold | 101...115 % of Motor nominal voltage in increments of 1 % | 110 % of Motor nominal voltage |
| Overvoltage trip timeout | 0.2...25 s in increments of 0.1 s | 3 s |
| Overvoltage alarm enable | • Disable | Disable |
| | • Enable | |
| Overvoltage alarm threshold | 101...115 % of Motor nominal voltage in increments of 1 % | 110 % of Motor nominal voltage |

## Voltage Dip

| Parameters | Setting range | Factory setting |
|---|---|---|
| Voltage dip mode | • None | None |
| | • Load shedding | |
| | • Auto-restart | |
| Voltage dip threshold | 50...115 % of Motor nominal voltage in increments of 1 % | 65 % of Motor nominal voltage |

| | | | |
|---|---|---|---|
| Load shedding timeout | 1...9999 s in increments of 1 s | 10 s | |
| Voltage dip restart threshold | 65...115 % of Motor nominal voltage in increments of 1 % | 90 % of Motor nominal voltage | |
| Voltage dip restart timeout | 0...9999 s in increments of 1 s | 2 s | |
| Voltage dip threshold | 50...115 % of Motor nominal voltage in increments of 1 % | 65 % of Motor nominal voltage | |
| Voltage dip restart threshold | 65...115 % of Motor nominal voltage in increments of 1 % | 90 % of Motor nominal voltage | |
| Voltage dip restart timeout | 0...9999 s in increments of 1 s | 2 s | |
| Auto restart immediate timeout | 0...0.4 s in increments of 0.1 s | 0.2 s | |
| Auto restart delayed timeout | 0...301 s in increments of 1 s | 4 s | |

## Power

### Underpower

| **Parameters** | **Setting range** | **Factory setting** | |
|---|---|---|---|
| Underpower trip enable | • Disable | Disable | |
| | • Enable | | |
| Underpower trip threshold | 20...800 % of Motor nominal power in increments of 1 % | 20 % of Motor nominal power | |
| Underpower trip timeout | 1...100 s in increments of 1 s | 60 s | |
| Underpower alarm enable | • Disable | Disable | |
| | • Enable | | |
| Underpower alarm threshold | 20...800 % of Motor nominal power in increments of 1 % | 30 % of Motor nominal power | |

### Overpower

| **Parameters** | **Setting range** | **Factory setting** | |
|---|---|---|---|

| | | |
|---|---|---|
| Overpower trip enable | • Disable | Disable |
| | • Enable | |
| Overpower trip threshold | 20...800 % of Motor nominal power in increments of 1 % | 150 % of Motor nominal power |
| Overpower trip timeout | 1...100 s in increments of 1 s | 60 s |
| Overpower alarm enable | • Disable | Disable |
| | • Enable | |
| Overpower alarm threshold | 20...800 % of Motor nominal power in increments of 1 % | 150 % of Motor nominal power |

## Under Power Factor

| **Parameters** | **Setting range** | **Factory setting** |
|---|---|---|
| Under power factor trip enable | • Disable | Disable |
| | • Enable | |
| Under power factor trip threshold | 0...1 in increments of 0.01 | 0.6 |
| Under power factor trip timeout | 1...25 s in increments of 0.1 s | 10 s |
| Under power factor alarm enable | • Disable | Disable |
| | • Enable | |
| Under power factor alarm threshold | 0...1 in increments of 0.01 | 0.6 |

## Over Power Factor

| **Parameters** | **Setting range** | **Factory setting** |
|---|---|---|
| Over power factor trip enable | • Disable | Disable |

| | | | |
|---|---|---|---|
| | • Enable | | |
| Over power factor trip threshold | 0...1 in increments of 0.01 | 0.9 | |
| Under power factor trip timeout | 1...25 s in increments of 0.1 s | 10 s | |
| Over power factor alarm enable | • Disable | Disable | |
| | • Enable | | |
| Over power factor alarm threshold | 0...1 in increments of 0.01 | 0.9 | |

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## IEC Format Wiring Diagrams

### Overview

This section contains the wiring diagrams corresponding to the five pre-configured operating modes:

| | |
|---|---|
| Overload | Monitoring of the motor load where control (start/stop) of the motor load is achieved by a mechanism oth controller |
| Independent | Direct-on-line (across-the-line) full-voltage non-reversing motor starting applications |
| Reverser | Direct-on-line (across-the-line) full-voltage reversing motor starting applications |

| | |
|---|---|
| Two-Step | Reduced voltage starting motor applications, including: |
| | • Wye-Delta |
| | • Open Transition Primary Resistor |
| | • Open Transition Autotransformer |
| Two-Speed | Two-speed motor applications for motor types, including: |
| | • Dahlander (consequent pole) |
| | • Pole Changer |

Each application is described individually, with:

| | |
|---|---|
| One complete application diagram | 3-wire (impulse) terminal strip control |
| (including power and control) | |
| Three partial diagrams | 2-wire (maintained) terminal strip control |
| (control logic input wiring variants) | 3-wire (impulse) terminal strip control with network control selectable |
| | 2-wire (maintained) terminal strip control with network control selectable |

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· · IEC Format Wiring Diagrams
· NEMA Format Wiring Diagrams
o Overload Mode Wiring Diagrams

o Independent Mode Wiring Diagrams

o Reverser Mode Wiring Diagrams

o Two-Step Wye-Delta Mode Wiring Diagrams

o Two-Step Primary Resistor Mode Wiring Diagrams

o Two-Step Autotransformer Mode Wiring Diagrams

o Two-Speed Mode Wiring Diagrams: Single Winding (Consequent Pole)

o Two-Speed Mode Wiring Diagrams: Separate Winding

· Glossary Matrix-UPS frequently asked questions regarding installation, operation, and standards

**Article available in these languages:** Spanish

**Issue**

Where can I find the answers to commonly asked questions about the Matrix UPS?

**Product Line**

Matrix UPS

**Environment**

All serial ranges

**Cause**

Some common questions may arise during the installation or use of a Matrix UPS.

**Resolution**

This document provides the answers to commonly asked questions regarding installation of the APC Matrix UPS.

Installation Hints

1. Matrix-UPS should be set up on a solid level surface if possible. Padding on floor will help dampen system noise.
2. User needs to know input voltage to Matrix-UPS. If 240VAC input, Matrix-UPS Input Select Tap Wire must be moved.
3. Set Matrix-UPS EU (Electronics Unit, the top half of the unit) in place on top of Matrix-UPS IU (Isolation Unit, the bottom half of the unit) an tighten rear knob.
4. Add SmartCell battery packs to system, either on top of Matrix-UPS or by its side.
5. Hook Anderson connector from SmartCell battery pack to EU slot, then add SmartCell communications cable.

Note: Battery communication cable must go from EU's "batt com" input to the "output" marking of first SmartCell. Follow this pattern for additi battery packs.

6. Once all pieces are connected, turn main circuit breaker located on the rear of Matrix-UPS IU to "ON" position.
7. Front LCD display should read On-line with a % load. If LCD display does not illuminate, press all three buttons found directly underneath the simultaneously.
8. User can then scroll through menu option of the LCD display to check current Matrix-UPS settings.
9. Change the sensitivity setting to LOW (default is AUTO). This LOW setting is preferred.
10. Go to menu "UPS Tests" and perform a battery test.

Matrix-UPS Noises

The Matrix-UPS will make certain noises which are normal to its operation and are acceptable. If the noise is not typical there will probably be ot their causes.

| |
|---|
| 1. Loud Hum - This sound will be heard anytime the transformer is energizing (usually on startup) and is normal. The physical size of the tran this sound. |
| 2. Beeping - The Matrix-UPS will make different beeps depending on the UPS condition or fault. |
| Line Failure - four beeps about every five seconds |
| Bypass - one beep every four seconds |
| Bypass with no battery communication - five beeps |
| Line failure with no battery communication - Continuous beeping |
| Failed self test - Chirping |
| 3. Clicking/Fineline Output Regulation |
| This sound will be heard anytime the Matrix-UPS is adjusting taps for voltage regulation, the Matrix-UPS will maintain +/- 5 % on the output menu, "UPS Setup", on the front LCD display of the Matrix-UPS Electronics Unit (EU, the top half of the unit) and change the setting from " |
| |
| a ) The Matrix-UPS features a tap changing regulator at the input with 6 taps. |
| b ) Through proper selection of the input tap, the output voltage is maintained to within a narrow band; typically 5% of rated input voltage. |
| c ) Intelligent tap changer adapts to varying line conditions from the front LCD display "UPS Setup" menu. |
| d ) If any fault in the tap changer is detected the unit switches itself into bypass and displays "main relay fault" on the front LCD display. |
| |
| |
| Matrix-UPS Certifications, Listings and Safety Agency Approvals |
| |
| **UL listed,** File # E95463: category YEDU - UPS Equipment, per UL 1778 |
| **CSA certified,** File # LR63938: class 5311 05 - Power Supplies (Stand Alone), per standards C22.2 No 0, C22.2 No 0.4, C22.2 No 66, C22.2 No 107.1 |
| **TUV certified:** per standards EN 60 950 and VDE 0558 (IEC 146-4) |
| **Novell Labs approved:** NetWare compatible |
| **FCC verified:** per FCC Rules Part 15, Class A Computing Devices |

**EC verified:** per EN50082-1, EN50091-1, EN55022 Class A

**VCCI Class 1:** ITE

**Note:** The Matrix-UPS is not UL1449 approved

EMI / RFI

The Matrix-UPS and SmartCell system were tested to withstand radiated electromagnetic (EM) fields per the test methods of IEC standard 801.3 vertical and horizontal polarization. The Matrix-UPS meets the FCC Part 15 Class A computing device and CISPR 22 (EN 55022) Class A radiat

Matrix-UPS Thermal Dissipation

| Matrix-UPS 3000 | Matrix-UPS 5000 |
|---|---|
| On-Line 540 BTU/hr | On-Line 900 BTU/hr |
| On-Line/Charging 900BTU/hr | On-Line/Charging 1260 BTU/hr |
| On-Battery 2000 BTU/hr | On-Battery 3700 BTU/hr |

Matrix-UPS Overload Rating

When the Matrix-UPS is on-line and overloaded, the input circuit breaker clearing times below can be expected.

| Overload | Min. Time | Max. Time |
|---|---|---|
| 200% | 10 sec. | 100 sec. |
| 500% | 1 sec. | 10 sec. |
| 1000% | 6 msec. | 2 sec. |
| 1200% | 5 msec. | 1 sec. |

If the overload continues for this amount of time the breaker will trip forcing the Matrix-UPS to battery. When the Matrix-UPS is on battery the i within 4 seconds.

Matrix-UPS Input Voltage

The Matrix-UPS 3000 and 5000 models are wired from the factory for 208 VAC input. This can be verified a couple of ways once the unit is installed.

1 ) Go to the front display of the Matrix-UPS and scroll through to the menu "UPS Status" to check the input line voltage, in some cases this v or 240 VAC.

2 ) From the diagnostics menu you can view the UPS FW REV, this screen will show the internal micro revision of the Matrix-UPS which wi the letter "I" is displayed, the unit should be wired 240 VAC and the Input Voltage Select tap wire has been moved for that setting.

3 ) If the user inputs 240 VAC but did not move the Input Voltage Select wire, the letter "M" will show under UPS FW REV. The Matrix-UP stay on battery.

If the UPS Control menu selections are TURN UPS OFF and COLD START UPS, check the input voltage and circuit breaker. The UPS is no any input voltage.

Matrix-UPS De rating

The Matrix-UPS 5 kVA is rated to work with a 30 Amp electrical service. Due to National Electrical Code (NEC) and Underwriters Laborato current that the UPS can draw from a 30 Amp utility outlet to 24 Amps.

With 240 VAC input, the unit is allowed to draw up to 5760 VA, so it can support a 5 kVA load even after allowing for small losses inside th VA to the load in order to stay within the 24 Amps limit from the utility outlet.

Matrix-UPS Transfer Time

1 ) Matrix-UPS transfer times to and from bypass:

The transfer times to the bypass mode of operation differs depending upon how the Matrix-UPS is commanded to go to bypass. The transfer t how it is done.

- To Bypass - Commanded via the front panel display or

software, 1 ms typical

- Rear panel bypass switch, 4 ms typical
- Loosening the Electronics unit separating screw - 4 ms typical, 10 ms max.

- From Bypass - Via front display or rear panel switch - 0 ms typical

Note that all types of UPSs exhibit a transfer time in going to bypass. Most on-line UPSs with bypass exhibit up to 8 ms of transfer time. It shoul manufacturer.

2 ) How does the Matrix-UPS achieve a zero transfer time:

The Matrix-UPS provides no-break, zero transfer backup power for protected computer loads. This performance is achieved by a combination of elements:

- Filter Isolates power failure from the load: The filtering elements in the Matrix-UPS, including the isolation transformer serve to isolate power faults from the protected load. Therefore, even if the input AC instant

- High speed power fault detection: Power faults are detected by a high speed microprocessor in less than 200 microseconds. As soon as a fault is detected the load from any disturbance, giving the detector time to operate.
- Input fault disconnection: A high speed switch made up of solid state devices and a rugged electrodynamics (relay) components quickly disconnects the i the utility line from loading the inverter if the utility line is a low impedance state.

**Inverter is already on-line: The power inverter converts battery power to AC is already connected to the output at all times due to the line interactive to** transfer or other switches are necessary to connect the inverter to the load when the power fails.

The line interactive design of the Matrix-UPS does have power fault and corrections systems that take time to operate, but these brief delay times long enough to allow the inverter to reverse power flow and disconnect the input fault.

Matrix-UPS vs. Ferro resonant UPS

The Ferro resonant UPS (or FerrUPS) is not only limited in its manageability but also very inflexible when changing platforms. Matrix-UPS supp Efficiency with FerrUPS: At full load, the FerrUPS runs at 80% efficiency, compared to the 93% efficiency at full load for the Matrix-UPS. Fully

inrush current. As the load is reduced, the FerrUPS efficiency drops much faster than the Matrix-UPS. At 60% load, a Ferro resonant based U

Compared to the isolation transformer, ferroresonant transformers are heavy, emit much heat, noisy, and large in size. Also, the ferro's tank ci
cause the transformer's magnetic field to collapse. This is very important when on-site generation of power is used like a generator.

Matrix-UPS Efficiency

| Matrix-UPS 3000 | Matrix-UPS 5000 |
|---|---|
| 25% load > 84% | 25% load > 82% |
| 50% load > 90% | 50% load > 89% |
| 75% load > 91% | 75% load > 91% |
| 100% load > 92% | 100% load > 93% |

Matrix-UPS - "W" & "J" Options

Japanese Model

The Japanese Matrix-UPS requires an input voltage of either 200 VAC or 208 VAC. The output voltage can either be 100/200 VAC or 120/208/240 VAC as
the Matrix-UPS "J" IU are similar to that of the domestic Matrix-UPS, with the addition of an L11-30R twist-lock receptacle which provides voltages of 20

Worldwide Model

The Matrix-UPS "W" (worldwide) has the ability to operate on a frequency of either 50 or 60HZ. **The unit is almost identical to the domestic Matrix and**
line.

Note: the MX5000J-EU can be used on a MX5000 worldwide or MX5000 domestic.

Options

The Matrix-UPS "W" (worldwide) has the ability to output 120 VAC by changing it's standard configuration. This is accomplished by either replacing the s

| APC Part Number | Description |
|---|---|

| | |
|---|---|
| MXA001 | MX5000 Hardwire Plate |
| MXA002 | MX3000 Hardwire Plate |
| MXA005 | Meridian Alarm Cable Kit |
| MXA006 | Matrix casters |
| MXA007 | Matrix Rack Shelf |
| MXA008 | SmartCell Extender Cables |
| MXA101 | PDU - 10 5-15R, 1 L14-30R |
| MXA102 | PDU - 4 L6-20R |
| MXA103 | PDU - 8 5 - 20R |
| MXA104 | PDU - 4 L6-30R |
| MXA105 | PDU - 4 L5 - 30R |
| MXA106 | PDU - 4 L5 - 20R |
| MXA107 | PDU - 4 L6-15R, 4 6-15R, 1 L6-30R |
| MXA108 | PDU - 6 L5-15R, 2 L14-30R |

Harmonics

Computers are non-linear loads that cause harmonics to flow in the power lines. Harmonics are currents that are multiples of the fundamental line frequenc

- Harmonics overload the neutral wiring in buildings and create a potential fire hazard.

- Harmonics overload building power transformers and cause them to wear out.

Matrix-UPS helps reduce harmonics problems in the following ways:

- Matrix-UPS eliminates neutral currents: The Matrix-UPS does not use or need a neutral connection on its input. Matrix-UPS gets its input power from two current heating problem in anyway.

- Matrix-UPS reduces harmonics current in the hot wires: The Matrix-UPS reduces these currents in two ways. Matrix-UPS improves power factor and a
36%.

Galvanic Isolation

Galvanic Isolation means that the output power circuit is electrically and physically isolated from the input power circuit. Electrical isolation
already have galvanic isolation between the input power and the computer logic built. This is a requirement of international safety agencies in
transformers only isolate the power wires, but pass the ground wire straight through. The actual affect of installing an isolation transformer is

Matrix-UPS and Batteries:

The Matrix-UPS has the ability to tell you many things about a user's site and often can provide the information needed to diagnose a problem
Compiling enough information around a problem will often help paint a picture of what is wrong when you cannot see it another way. Use the

1 ) Line Voltage
2 ) Output Voltage
3 ) % Load
4 ) Battery Voltage
5 ) Last Reason for Transfer
6 ) Battery Capacity
7 ) Number of Batteries
8 ) Number of Bad Batteries
9 ) Internal Temperature
10 ) Bypass Enable/Disable
11 ) UPS FW Rev

The items in the above list may seem obvious but they play an important role in the diagnosis of the problem. From this data the next level of
information should help to quickly isolate which of the modules are having the problem.

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# Campus LAN and Wireless LAN Solution Design Guide

Updated:May 4, 2020

## Campus quality of service (QoS)

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## Definition and Introduction: Campus LAN and Wireless LAN

There is a tendency to discount the network as simple plumbing — to believe that the only design considerations are the size and the length of the
purpose, redundancy, protection from tampering or denial of operation, and the capacity to handle peak loads, the network requires similar consid
network must be able to provide resilient, intelligent transport. The reliable network design also needs to incorporate versatility in order to addres

Here are some key concepts that you should address when creating a reliable and versatile network design. The network should be:

- **Always on and resilient**—Continuously on and available.
- **Intelligent**—Adapting to changing needs, beyond the limits of basic standards, using insight into network activity.
- **Secure**—Protecting the organization and its users.

### Planning for the Future

As you look at a network design, consider the networking trends and future needs of an organization.

- The network must be ready to appropriately scale over time in order to meet the demands of the organization it is supporting.
- Because demands on wireless access points (APs) with the latest standards, including Wi-Fi 6 (802.11ax) technology exceed 1 Gbps, and the I
upgrade of the existing copper Ethernet wiring plant. You accommodate these latest demands by deploying network platforms including Cisco®
- As you deploy new devices with higher power requirements, such as lighting, surveillance cameras, virtual desktop terminals, remote access sw
access layer should also provide PoE perpetual power during switch upgrade and reboot events. The Cisco Catalyst 9000 Series access layer swit
- Compliance issues drive a choice of platforms required when you support standards certifications and MACsec. For those cases, you should al
as NetFlow.
- The Internet of Things (IoT) impacts today's network design. Your network should support TrustSec and other segmentation and virtualization
by these trends.
- Bandwidth needs are doubling potentially multiple times over the lifetime of a network so that the network deployed today needs to be prepare
or more over time.
- The network platforms deployed today should offer the best longevity into the future, versus selecting the equipment that only meets the limits
today's needs.
- To reduce operational complexity, you can use a centralized controller with open APIs, allowing for very fast, lower-risk deployment of netwo
network device configuration and management to achieve your organization's intent.

### Cisco Digital Network Architecture (Cisco DNA)

Cisco Digital Network Architecture (Cisco DNA) provides a roadmap to digitization and a path to realize immediate benefits of network automat

of the word campus does not imply any specific geographic size or organizational boundary—the campus LAN can range in size from a singl
their daily activities. The campus design incorporates both wired LAN and wireless LAN connectivity for a complete network access solution

- The design of the campus wired LAN foundation.
- How the WLAN extends secure network access or is exclusive network access for your mobile workforce.
- How the WLAN can provide guest access for contractors and visitors to your facilities.

If you didn't download this guide from Cisco Community or Design Zone, you can check for the latest version of this guide.

Find related deployment guides, design guides, and white papers, at the following pages:

- https://www.cisco.com/go/designzone
- https://cs.co/en-cvds

Design: Campus LAN and Wireless LAN

Designing a LAN for the campus use case is not a one-design-fits-all proposition. The scale of campus LAN can be as simple as a single swit
require very high availability for the services offered by the network, with a low tolerance for risk, or there may be tolerance for fix-on-failure
capacity, the device and network capabilities offered, and the need to meet any compliance requirements that are important to the organizatio

- Traditional Access- Dedicated Distribution and Access Layers (L2 or L3). You impose most of the campus wired LAN design complexity
communicate with a Layer 2 logical adjacency and those connections cover multiple physical wiring closets connected to a distribution layer,
configurations with additional protocols that must be kept consistent across multiple devices.
- Simplified Access –Virtualized StackWise Access & StackWise Virtual Distribution. To improve the design, there are preferred alternativ
layer using options such as a switch stack or a StackWise Virtual system, and the simplified access layer using a switch stack with StackWise
- Cisco Software Defined Access – Campus Fabric and Automation of the Distribution & Access Layers. A design alternative is available fo
functionality, such as when using fabric technology for campus designs—an integral part of Cisco SD-Access. The alternative to the Layer 2
scalability, and high availability of the network versus the traditional multilayer campus design.

The motivation for the recommended design choices is not that they are the only options available but that the recommendations highlight pre
the design is not one that is typically recommended considering better alternatives that are currently available.

When you integrate the wireless components of the campus design with the wired components, the design can often be treated as an overlay t
dedicated devices becomes a requirement. Smaller networks, such as those at small remote sites, offer opportunities for simplification and opt

The primary design options are grouped by scale, and then appropriate selections are based on the capabilities desired. The selection from the
deployment.

## Design Fundamentals: Campus Wired LAN

The LAN is the networking infrastructure that provides access to network communication services and resources for end users and devices spread concepts include small networks that use a single LAN switch, up to very large networks with thousands of connections.

The campus wired LAN enables communications between devices in a building or group of buildings, as well as interconnection to the WAN and network core.

Specifically, this design provides a network foundation and services that enable:

- Tiered LAN connectivity.
- Wired network access for employees.
- IP Multicast for efficient data distribution.
- Wired infrastructure ready for multimedia services.

### Hierarchical design model

The campus wired LAN uses a hierarchical design model to break the design up into modular groups or layers. Breaking the design up into layers management of the network.

Modularity in network design allows you to create design elements that can be replicated throughout the network. Replication provides an easy w method.

In flat or meshed network architectures, changes tend to affect a large number of systems. Hierarchical design helps constrain operational change improve resiliency.

Modular structuring of the network into small, easy-to-understand elements also facilitates resiliency via improved fault isolation.

A hierarchical LAN design includes the following three layers:

- **Access layer**—Provides endpoints and users direct access to the network
- **Distribution layer**—Aggregates access layers and provides connectivity to services
- **Core layer**—Provides connectivity between distribution layers for large LAN environments

Figure 1. LAN hierarchical design

Each layer —access, distribution, and core— provides different functionality and capability to the network. Depending on the characteristics
distribution layers, while a campus of multiple buildings will most likely require all three layers.

Regardless of how many layers are implemented at a location, the modularity of this design ensures that each layer will provide the same serv
design methods.

Figure 2. Scalability by using a modular design

Access layer

The access layer is where user-controlled devices, user-accessible devices, and other end-point devices are connected to the network. The acc
the entire network.

Figure 3. Access layer connectivity

- **Device connectivity**—The access layer provides high-bandwidth device connectivity. To help make the network a transparent part of an end-u

opening a file from an internal web page.

Because many types of end-user devices connect at the access layer —personal computers, IP phones, wireless APs, and IP video surveillance ca

and security.

- **Resiliency and security services**—The access-layer design must ensure that the network is available for all users who need it, whenever they

This protection includes ensuring that users have access only to authorized services, preventing end-user devices from taking over the role of othe

- **Advanced technology capabilities**—The access layer provides a set of network services that support advanced technologies, such as voice an

from other devices and to ensure efficient delivery of traffic that is needed by many devices in the network.

Multigigabit Ethernet (mGig) and PoE at the access-layer

As customers migrate to 802.11ax (Wi-Fi 6), the access layer switch platforms to which the Catalyst 9100 Series APs connect may also need to b

The higher MIMO rates of these APs, along with the rapid adoption of IoT devices is also driving the requirement for higher PoE requirements (P

Oversubscription ratios

The migration to mGig may also require increasing uplink port speeds in order to maintain the desired oversubscription ratio. Determining the ov

consideration the number of access ports on the switch which support mGig, since not all switches support mGig on all ports. You also need to ta

may be capable of operating at 10 Gbps, Cisco Catalyst 9100 Series APs only operate at mGig speeds up to 5 Gbps currently.

For example, let's say you deploy a 48-port switch which supports mGig up to 10 Gbps on 12 access ports, 1 Gbps on the other 36 ports, and witl

all uplinks are active – as in a Multichassis EtherChannel (MEC) configuration.

Figure 4. Example oversubscription ratio – single access-layer switch

The maximum potential bandwidth usage of the switch ports would be 12 x 10 Gbps = 120 Gbps plus 36 x 1Gbps = 36 Gbps, for a total 156 G
were operating at 10 Gbps.

More realistically, you may have the following actually connected to the switch:

- 8 Catalyst 9100 Series APs operating at 5 Gbps connected to the switch ports
- 32 Cisco IP Phones and/or end-user devices (PCs, Mac's etc.) operating at 1 Gbps connected to the switch ports
- 8 Unused ports for future expansion and capacity

The actual potential bandwidth usage of the switch ports would be 8 x 5 Gbps = 40 Gbps plus 32 x 1 Gbps = 32 Gbps, for a total 72 Gbps. Th
Gbps, or 3.6:1.

This configuration provides for additional capacity, in that you have an additional 2 x 10 Gbps unused uplinks as additional devices require m
configuration

Switch stack configurations

Migrating to a switch stack is an effective, flexible, and scalable solution to expand network capacity at the access-layer. The benefits of a sw
are as follows:

- The switch stack behaves as a single device (characteristics and functionality of a single switch)
- The switch stack allows expansion of switch ports without having to manage multiple devices
- Switches can be added or removed from the switch stack without affecting the overall operation of the switch stack
- Depending upon the configuration of the switch stack, it can continue to transmit data even if a link or switch within the stack fails

When adding additional access layer switches in a stackable configuration, you should design the switch stack with the desired oversubscripti
within the stack.

Figure 5. Example oversubscription ratio – access-layer switch stack

For example, let’s say you deploy four 48-port switches each of which supports mGig up to 10 Gbps on 12 access ports, 1 Gbps on the other 36 p
provide up to 40 Gbps uplink bandwidth in a MEC configuration, when both switches are operational. However, you now have 192 access ports.
The maximum potential bandwidth usage of the switch ports would be 48 x 10 Gbps = 480 Gbps plus 144 x 1 Gbps = 144 Gbps, for a total 624 G
ports were being used.

More realistically, you may have the following actually connected to the switch:

- 32 Catalyst 9100 Series APs operating at 5 Gbps connected across the switch stack
- 128 Cisco IP Phones and/or end-user devices (PCs, Mac’s etc.) operating at 1 Gbps connected across the switch stack
- 32 unused ports across the switch stack for future capacity

The actual potential bandwidth usage of the switch ports would be 32 x 5 Gbps = 160 Gbps plus 128 x 1 Gbps = 128 Gbps, for a total 288 Gbps.
Gbps : 40 Gbps, or 7.2:1.

Again, this configuration provides for additional capacity, in that you have an additional 12 x 10 Gbps unused uplinks across the switch stack, as
the switch stack.

If one of the switches with uplinks were to fail, the number of uplinks decreases to 2 x 10 Gbps. However, the number of ports also decreases by
oversubscription ratio. For example, APs operating at 5 Gbps should be spread equally across the switches in the stack. This is already a best pra
switches with uplinks were to fail, the actual oversubscription ratio would increase from approximately 7:2:1 to 10.8:1.

Another best practice is to select switches without uplinks as the active and standby of the switch stack, as shown in the figure above. Uplinks sh
both the active switch and half of your uplinks.

Modular access layer switch platforms

An alternative to deploying switch stacks at the access layer is to deploy modular switch platforms, such as the Catalyst 9400 Series. Catalyst 94
IDFs (wiring closets).

An advantage of modular platforms is that additional linecards can be added to empty slots within the chassis to increase capacity, without having

houses the modular switch. Adding an additional linecard may also be less expensive than purchasing another stackable or standalone switch

Another advantage of modular platforms is that they are typically designed such that the supervisor can be upgraded to increase the performa
be deployed to provide chassis-level high availability such as Non-Stop Forwarding (NSF) and Stateful Switchover (SSO) – similar to the act

As with switch stacks, uplinks should be spread across linecards within the modular chassis. Oversubscription ratios should be determined bo
failure a single linecard within a modular chassis.

Increasing uplink speeds

As you continue to add more switches to a switch stack you must keep in mind the distribution of the uplinks across the switches in the switch
distribution of the uplinks across the linecards, and the oversubscription ratio during linecard failure scenarios.

Deploying multiple 10 Gbps uplinks may not be effective for larger switch stacks or modular platforms when migrating to mGig capable swit
eight 10 Gbps switch ports across the distribution layer switches, for each access layer switch or switch stack.

Hence, it may be more optimal to migrate to higher speed uplinks between the access layer switch or switch stack and the distribution layer
switches.

Figure 6. Example oversubscription ratio – access-layer switch stack with 25 Gbps uplinks

For example, instead of deploying four 48-port switches with fixed 4 x 10 Gbps uplinks in a switch stack configuration, you may want to dep
within the stack.

This configuration provides up to 100 Gbps uplink bandwidth in a MEC configuration, when both switches with uplinks are operational. Few
and each of the access layer switch stacks. However, when deciding to upgrade the uplink speeds between the access and distribution-layer s

- The optical transceiver modules which connect the distribution layer switches to the access layer switch platforms have to interoperate with
mode fiber (SMF).

**Note:** Cisco offers a gradual migration path with the support of dual-rate optics, where the same 25 Gbps optics can operate at both 10 Gbps
layer switches can be upgraded over a period of time.

- The distances supported by multimode fiber typically decrease as speeds increase. This means that if you are upgrading from 10 Gbps to 25 G to determine if the cabling will support the distances between the main IDF (which may house the distribution layer switches) and the floor IDFs equipment within the racks.

**Note:** The Cisco 10/25GBASE-CSR Module supports a link length of up to 300/400m over OM3/4 at 10G, and up to 300/400m over OM3/4 at FEC on the host port for full reach operation at 25G. Using BASE-R FEC the module can support 70/100m over OM3/4 and with-out FEC it can

- If you have older multimode fiber (OM1), speeds above 10 Gbps may not be supported.

Single mode fiber generally supports both higher transmission rates and longer distances than multimode fiber.

Uplink queuing

The actual uplink oversubscription ratio that you implement between your access and distribution layer switches is dependent upon your business implemented in networks. The higher the oversubscription ratio, the higher the probability that temporary or transient congestion of the uplink ma

Catalyst 9000 Series switches dynamically allocate buffer space across switch ports and queues in order to optimize the utilization of the existing UADP ASIC and the number of UADP ASICS within the switch platform). During periods of temporary congestion the buffers on individual sw

It is recommended to implement queuing on switches, where oversubscription of ports can result in transient congestion, which can cause packet treatment over lower priority traffic. This preserves the quality of experience for your business critical applications, such as voice.

Access layer variations

In some situations, such as for IoT and for multi-dwelling unit (MDU) deployments, the access layer is often augmented with additional cascaded deployments the devices may be small distributed access switches or gigabit passive optical network (GPON) optical network termination device

Access layer platforms

The preferred options for the campus wired LAN include the following Cisco switches as platforms for the access layer:

- Cisco Catalyst 9400 Series Switches (modular chassis)
- Cisco Catalyst 9300 and 9300-L Series Switches
- Cisco Catalyst 9200 and 9200-L Series Switches

Distribution layer

The distribution layer supports many important services. In a network where connectivity needs to traverse the LAN end-to-end, whether between connectivity.

- **Scalability**—At any site with more than two or three access-layer devices, it is impractical to interconnect all access switches. The distribution layer switches.

The distribution layer can lower operating costs by making the network more efficient, by requiring less memory, by creating fault domains that c network availability by containing failures to smaller domains.

- **Reduce complexity and increase resiliency**—The campus wired LAN has the option to use a simplified distribution layer, in which a distribu

using a physical stack of switches operating as one device. Resiliency is provided by physically redundant components like power supplies, su

This approach reduces complexity of configuring and operating the distribution layer because fewer protocols are required. Little or no tuning failures or disruptions.

Two-tier design

The distribution layer provides connectivity to network-based services, to the WAN, and to the Internet edge. Network-based services can inc the WAN and Internet edge may reside on a distribution layer switch that also aggregates the LAN access-layer connectivity. This is also refe

Figure 7. Two-tier design: Distribution layer functioning as a collapsed core

Three-tier design

Larger LAN designs require a dedicated distribution layer for network-based services versus sharing connectivity with access layer devices. As th
hard to manage. When connecting at least three distributions together, using a core layer for distribution connectivity should be a consideration.

There are several factors that drive LAN design with multiple distribution layer modules:

- The number of ports and port bandwidth that the distribution layer platform can provide affects network performance and throughput.
- Network resilience is a factor when all LAN and network-based services rely on a single platform, regardless of that platform's design, it can p
failure domain.
- Change control and frequency affects resilience. When all LAN, WAN, and other network services are consolidated on a single distribution lay
network operation.
- Geographic dispersion of the LAN access switches across many buildings in a larger campus facility would require more fiber optic interconne
collapsed core.

Like the access layer, the distribution layer also provides quality of service (QoS) for application flows to guarantee critical applications and mult
designed.

Figure 8. Three-tier design with a network-services distribution layer

Distribution layer platforms

The preferred Cisco switches for deploying the distribution layer of the campus wired LAN include:

- Cisco Catalyst 9600 Series Switches (modular chassis)
- Cisco Catalyst 9500 Series Switches
- Cisco Catalyst 9400 Series Switches (modular chassis)

Core layer

In a large LAN environment, there often arises a need to have multiple distribution layer switches. One reason for this is that when access lay
in each of those buildings. As networks grow beyond three distribution layers in a single location, organizations should use a core layer to opt

Another reason to use multiple distribution layer switches is when the number of access layer switches connecting to a single distribution laye
connectivity, or Internet edge services.

In environments where multiple distribution layer switches exist in close proximity and where fiber optics provide the ability for high-bandwi
shown in the following two figures.

Figure 9. LAN topology with a core layer

Figure 10. LAN topology without a core layer

The core layer of the LAN is a critical part of the scalable network and, by design, is one of the simplest. The distribution layer provides the fault
where connectivity to resources to conduct business is critical. Connectivity to and from the core is Layer 3–only, which drives increased resilien

Oversubscription ratios

For three-tiered designs, increasing the uplink speeds between the access and distribution layer switches may also require increasing uplink speed
oversubscription ratio.

Determining the oversubscription ratio of the uplink between the distribution and core layer switches is fairly straight forward. You need to take
which the ports are operating.

Figure 11. Oversubscription between the distribution and core layer switches – 40 Gbps uplinks

For example, let's say your distribution layer switch is a StackWise Virtual pair that supports a building with 4 floors. Each floor has two ID
stack. The total number of 25 Gbps ports required at the distribution layer switches is 4 uplinks x 2 IDFs per floor x 4 floors = 32 ports.

This configuration would provide up to 32 x 25 Gbps = 800 Gbps bandwidth between the distribution layer and access layer switches. Simply
ratio of 800:80 or 10:1 between the distribution and core layers. Depending upon your business requirements, this may be insufficient.

Increasing Uplink Speeds

You could choose to add additional 40 Gbps links between the distribution and core layer switches, possibly operating in a Layer 3 EtherChan
additional fiber optic pairs between the distribution layer switches and the core layer switches.

In a large campus deployment, the core layer switches may be located in a centralized data center in a different building. If insufficient optica
proposition, as existing conduit space between the buildings may not be capable of supporting additional cabling, and you run the risk of dam
underground conduit – on top of the cost to install the new fiber optic cable.

An alternative may be to upgrade the uplink speeds between the distribution layer and core layer switches to 100
Gbps.

Figure 12. Oversubscription between the distribution and core layer switches – 100 Gbps uplinks

This would provide an oversubscription ratio of 800:200 or 4:1 between the distribution and core layers.

As with the access layer, when deciding to upgrade the uplink speeds between the distribution layer switches and the core layer switches, you sho following:

- The optical transceiver modules which connect the distribution layer switches to the core layer switch platforms have to interoperate with each buildings.

Due to the increased distances between buildings, single mode fiber (SMF) may already be installed between the distribution and core layer switc and core layers.

Core layer platforms

The preferred Cisco switches used as campus platforms for the core layer
are:

- Cisco Catalyst 9600 Series Switches (modular chassis)
- Cisco Catalyst 9500 Series Switches

The capacity, density, and features are the primary differences driving platform selection. Both lead platforms have sibling platforms that may be are not required.

Design Options: Campus Wired LAN

When you scale from a single switch in a campus LAN up to a full three-tier campus network, the reliability of the network is increasingly impor of network resources, campus designs include additional resiliency options, such as redundant links, switches, and switch components. In traditio access and aggregation layers of the campus LAN.

The primary function of the distribution layer is to aggregate access layer switches in a given building or campus. The distribution layer provides functions for the LAN. On the Layer 2 side, the distribution layer creates a boundary for spanning tree protocol (STP), limiting propagation of La reduces IP route tables for easier troubleshooting and reduces protocol overhead for faster recovery from failures.

Layer 2 access with traditional multilayer campus design

Traditional LAN designs use a multi-tier approach with Layer 2 from the access layer to the distribution layer, where the Layer 3 boundary exists looped design.

In the traditional network design, the distribution layer has a pair of standalone switches for resiliency. It is recommended that you restrict a Laye of failure in LANs. Restricting a VLAN to a single switch provides a loop-free design, but it does limit network flexibility.

To create a resilient IP gateway for VLANs in the traditional design, you must use first-hop redundancy protocols (FHRP), which provide hosts w gateway redundancy protocols, but they only allow hosts to send data out one of the access uplinks to the distribution layer and require additional uplink utilization for traffic exiting the access layer by balancing load from hosts across multiple uplinks, but you can only use it in a non-looped

**Note:** All FHRP protocols require that you fine-tune the default timer settings in order to allow for sub-second network convergence, which ca resources.

Some organizations require the same Layer 2 VLAN be extended to multiple access layer closets to accommodate an application or service. T inefficiencies and the increased potential for misconfiguration drive network engineers to look for more appealing alternatives.

Figure 13. Traditional looped design with VLANs spanning access switches

Figure 14. Traditional loop-free design with a VLAN per access switch

The following is a summary of some of design and operational concerns with the traditional multilayer campus design, driving alternative approaches:

- Spanning-tree protocol looping behavior, including blocked links, slow convergence, asymmetric forwarding, and switch CAM and ARP table unicast flooding
- FHRP configuration consistency, slow convergence times driving protocol tuning in conflict with non-stop forwarding systems
- Layer 3 protocol tuning and protocol-dependent scale and recovery, multicast protocol configuration consistency and tuning, and general contr complexity

**Note:** The Flexlink+ feature of enables the user to configure a pair of a Layer 2 interfaces (trunk ports or port channels) where one interface is Protocol (STP).

Because of the design and operational concerns inherent in the traditional multilayer campus design, organizations strive to deploy different desig possible.

Layer 3 routed access campus design

In another approach to access and distribution layer design, you can use Layer 3 beyond just the core and distribution layers and configure Layer boundary between the Layer 2 access ports and outbound Layer 3 connectivity. The benefits of this design are that you eliminate spanning tree lo layer and increase effective bandwidth available to the users. This design makes it easy to maintain configuration consistency, while providing ex

Figure 15. Layer-3 Routed Access

The challenges with the routed access layer design is that the Layer 2 domains are confined to a single access closet, which limits flexibility for a functionality, and differences in IP addressing and subnetting must be accommodated. Many organizations have been unable to overcome the app

Preferred Layer 2 access using a simplified distribution layer campus design

An alternative that can handle Layer 2 access requirements and avoid the complexity of the traditional multilayer campus is called a Layer 2 acce

Virtual Pair (SVP), or the less preferred single, highly-redundant physical switch. One advantage of this design is that spanning tree depender

Even in the distributed VLAN design, you eliminate spanning tree blocked links because of looped topologies. You reduce dependence on sp
needed for additional bandwidth. At the same time, multiple links in an EtherChannel have better performance characteristics versus single in

Figure 16. Simplified distribution design with a VLAN per access switch

Figure 17. Simplified distribution design with VLANs spanning access switches

EtherChannel is a logical interface that can use a control plane protocol to manage the physical members of the bundle. It is better to run a dy
and provides protection to the system from inconsistent configurations. Cisco Catalyst switches provide both port aggregation protocol (PAgP

There are several other advantages to the simplified distribution layer design. You no longer need IP gateway redundancy protocols such as H
network will converge faster now that it is not depending on spanning tree to unblock links when a failure occurs, because EtherChannel prov

The topology of the network from the distribution layer to the access layer is logically a hub-and-spoke topology, which reduces complexity o
single logical designated router to forward IP Multicast packets to a given VLAN in the access layer.

Finally, by using the single logical distribution layer design, there are fewer boxes to manage, which reduces the amount of time spent on ong
as stateful switchover (SSO), non-stop forwarding (NSF), and in-service software upgrades (ISSU).

Cisco Software-Defined Access campus design

Another way to overcome the Layer 2 adjacency restrictions while still maintaining the advantages of the routed access layer design is by adding
technology are the decoupling of the Layer 2/Layer 3 forwarding plane of the endpoint/user from the underlay network, the unification of wired a
The addition of the fabric overlay is automated using Cisco DNA Center to deploy Cisco SD-Access technology. The Cisco SD-Access design en
alternative topologies to connect devices.

Figure 18. Cisco SD-Access campus design

Beyond traditional network virtualization, Cisco SD-Access allows for software-defined segmentation and policy enforcement based on user iden
unlike any alternative virtualization technology, Cisco SD-Access also inherently supports integration of the wireless LAN for a common policy
For additional information, see the Software-Designed Access Solution Design Guide.

Alternative virtualization design for campus——BGP EVPN VXLAN

For organizations not requiring the full automation and assurance support for macro and micro segmentation policies integrated with wireless
options available.

Traditionally, multiprotocol label switching (MPLS) technology or basic segmentation using VRF-Lite has been adapted to campus networks
(EVPN) overlays in the campus and, like Cisco SD-Access, has the option to use VXLAN encapsulation.

Unlike Cisco SD-Access, the control plane protocol for creating forwarding tables is BGP, and scales using the well-known concept of route
BGP (MP-BGP) control plane.

Figure 19. BGP EVPN VXLAN network topology

For organizations looking for an open standards-based overlay solution for their campus designs, and not needing the full intent-based networ
virtualization options.

## Design Fundamentals: LAN Security Best Practices

With any good network design, security must also be a focus. These tools below can help prevent attacks and make the network more secure and

**Note:** These are a few fundamental tools to help with basic network security, check out the Enterprise Security Design Guide for a more in dep security.

### DHCP Snooping

Rogue DHCP servers can be detrimental to the security and usability of the network if not protected against properly. Rogue DHCP servers attacl Users then looking to go to real websites will be sent to fake copies of these sites to steal credentials or information.

DHCP Snooping is a tool used to combat rogue DHCP servers. It works by assigning one or more ports as trusted, meaning these ports lead to leg from these untrusted hosts will be filtered of any DHCP server messages, blocking any attempt of a malicious DHCP server.

### Dynamic ARP Inspection

ARP cache poisoning is a malicious tool used to stage man-in-the middle attacks. It works by sending a forged ARP packet with the IP address of attacker can then forward the traffic to its intended destination making it look as if the traffic was never interrupted.

Dynamic ARP Inspection (DAI) is a tool that can be used to mitigate this threat. DAI uses the DHCP snooping database for IP to MAC address b binding is not valid.

### BPDU Guard

In L2 networks, loops can be your worst nightmare. To combat this, we use STP (Spanning Tree Protocol), but this can also be used to hurt the ne protect it.

In spanning tree, a root bridge is elected. This decides which ports will be put in a forwarding or blocking state. If a device is added with a lower from a wanted path.

BPDU guard is a protocol designed to solve this problem. When enabled, if a switch sees BDPU traffic coming from a port, it will automatically can pass.

### 802.1X

Authentication is very important for the security of the network. A potential attacker can sneak into a building and plug into an enabled network p to the network.

802.1X is an IEEE standard used for restricting unauthorized access to the network by making users authenticate before they are allowed onto the authentication.

- Supplicant – This is software which runs on the user device that collects credentials and forwards them to be authenticated.
- Authenticator – This is the network access device, usually a switch, the supplicant sends the user credentials to. The credentials are then forw
- Authentication server – This is a RADIUS server that validates the credentials based off information in its database.

| |
|---|
| Cisco Umbrella |
| With remote workers and sites being more prevalent in today's networks, it can be difficult to secure the network from malware and phishing attacks. |
| Cisco Umbrella provides a first line of security for wherever users access the internet by using DNS as a security tool. Since DNS is a core pa growing database built on machine learning and Internet activity patterns. This means Cisco Umbrella can identify and block threats before th |
| Cisco Umbrella also provides network administrators visibility of Internet activity across all endpoint devices on or off the corporate network accessed by users. |
| |
| |
| Design Fundamentals: LAN High Availability |
| To mitigate the concerns about unavailability of network resources, campus LAN designs include high availability / resiliency options, such a for updates and upgrades on the network. This section discusses high availability features specific to the LAN side of the network. |
| Stateful Switchover (SSO) |
| Stateful switchover (SSO) synchronizes active process information, as well as configuration information, between active and standby supervis immediately take over in sub-second time if the active supervisor / switch fails. |
| Non-stop Forwarding (NSF) |
| Non-stop forwarding (NSF) helps to suppress routing flaps in SSO enabled devices. NSF allows for graceful restart of L3 routing protocols, i switch switches over from the active to the hot-standby, it will continue switching IP data traffic flows in hardware. However, the device in t while the routing protocol information is being restored following a switchover. |
| Supervisor Redundancy |
| Cisco Catalyst C9404R, C9407R, C9410R, and C9606R chassis models support 1+1 supervisor redundancy (Sup-1, Sup1XL, or Sup-1XL-Y serves as a standby, monitoring the operation of the primary. Information is synchronized between supervisors to allow the standby supervisc forwarding during supervisor engine switchover. |
| **Note:** When implementing 1+1 supervisor engines on Catalyst 9400 Series switches, the active uplink ports are automatically spread across on the Catalyst 9600 Series, spread uplinks ports across the switch linecards. |
| StackWise Virtual Technology |
| StackWise Virtual technology combines two Catalyst 9000 Series switches into a single logical network entity from the network control plane StackWise Virtual pair as one bridge node, instead of two. StackWise Virtual technology uses SSO / NSF to provide seamless traffic failover device is designated as the active switch and the other is designated as the standby switch. All control plane functions are centrally managed |
| |
| Figure 20. StackWise Virtual Technology |

In order to bond the two switches together into a single logical node, special signaling and control information must be exchanged between the tw
peer switches. The SVL is formed as an EtherChannel interface of up to eight physical port members. It is recommended to have at least two ph

Switch Stacks and Cisco StackWise Technology

Cisco StackWise technology allows up to a maximum of eight switches to be stacked together physically in a ring topology to form a single, unif
data plane with a single control and management plane.

StackWise creates a unified control and management plane by electing one switch in the stack as the active switch and another switch as the hot-s
centrally manages all management plane and network control plane operations with Layer 2 and Layer 3 protocols. This information is synchron
from each Catalyst 9000 Series stack member switch, network services such as QoS, security ACLs, and others are distributed and programmed t
ring.

To optimally forward the traffic within the stack ring, the packet-stripping function is performed on the destination switch instead of on the sourc
switching architecture.

The following sub-sections discuss the StackWise implementation on Catalyst 9200 and 9300 Series switches.

Catalyst 9200 Series StackWise-160/80

Catalyst 9200 Series switches enable stacking of up to 8 switches and 416 ports using a stack-ring fabric known as either StackWise-160 or Stack
Catalyst 9200L switch models with the support of up to 80 Gbps stack bandwidth.

Catalyst 9300 Series StackWise-480/360

Catalyst 9300 Series switches enable stacking of up to 8 switches and 448 ports using a stack-ring fabric known as either StackWise-480 or Stack
Catalyst 9300L switch models with the support of up to 360 Gbps stack bandwidth.

EtherChannel

EtherChannel allows multiple physical Ethernet links to combine into one logical channel, allowing for load sharing of traffic among the links in
Multichassis EtherChannel (MEC) and cross-stack EtherChannel extend traditional EtherChannel by allowing Ethernet ports to be aggregated tov

Software Maintenance Upgrades (SMUs)

An SMU is a software package that can be installed on Catalyst 9000 Series switches to provide a patch fix for bugs or security resolution to an a
in device restart, reload, or switchover. Hot patching enables SMU to take effect after activation without the system having to be reloaded. After
affects the traffic flow for the duration of the reload. If a cold reload is required, users will be prompted to confirm the action.

**Note:** SMUs support patching using install mode only. SMUs are only supported on long-lived extended maintenance releases from IOS XE 16.6.1 on.

### In-Service Software Upgrades (ISSUs)

In-Service Software Upgrade (ISSU) is a process that upgrades an image to another image on a device while the network continues to forwar upgraded individually. ISSU is supported in Catalyst 9000 Series standalone and modular platforms (Catalyst 9400, 9500, and 9600 Series).

**Note:** ISSU is not supported for an upgrade from Cisco IOS XE Fuji 16.9.1 to Cisco IOS XE Fuji 16.9.2. ISSU from Cisco IOS XE Fuji 1 StackWise Virtual is supported starting from Cisco IOS XE Gibraltar 16.12.1. Therefore, ISSU upgrades can be performed only starting from

### Graceful Insertion and Removal (GIR)

GIR leverages redundant paths and existing routing protocols to gracefully isolate a device without impacting active flows. Conversely, GIR metrics of a network device that is about to undergo maintenance to make it a very unattractive path. It does this by inflating metrics or sendi Once the maintenance is complete, returning these metrics to their former values then smoothly restores normal traffic flow.

### Fast Software Upgrade (FSU) and Extended Fast Software Upgrade

During a software upgrade on the switch, user traffic is disrupted until the new software completely boots up. The traffic downtime is a conce software upgrade feature is supported on both stacking and standalone systems from IOS XE 16.8.1a and higher.

**Note:** Fast software upgrade is supported only on access switches with a single logical uplink connection. Fast software upgrade is not sup switch is configured as StackWise Virtual System.

Extended Fast Software Upgrade reduces the traffic downtime during software reload or upgrade operations. Compared to Fast Software Upg feature of Cisco NSF) to ensure that device configurations, such as certain routing protocols, remain unaffected during a software upgrade or

The following table summarizes high availability support with the various Catalyst 9000 Series switches.

**Table 1.** High availability feature support

| Platform | Switch Stacking | Supervisor Redundancy | NSF / SSO | EtherChan nel |
|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| | Cisco Catalyst 9200 Series | StackWise-160/80 with Active / Standby | — | Yes | Cross-Stack EtherChannel | N |

| | | | | | |
|---|---|---|---|---|---|
| | Cisco Catalyst 9300 Series | StackWise-480/360 with Active / Standby | — | Yes | Cross-Stack EtherChannel |
| | Cisco Catalyst 9400 Series | — | Single chassis 1:1 or cross chassis StackWise Virtual | Yes | Multichassis EtherChannel with StackWise Virtual |
| | Cisco Catalyst 9500 Series | — | Cross chassis StackWise Virtual | Yes | Multichassis EtherChannel with StackWise Virtual |

| | | | | | |
|---|---|---|---|---|---|
| Cisco Catalyst 9600 Series | — | Single chassis 1:1 or cross chassis StackWise Virtual | Yes | Multichassis EtherChannel with StackWise Virtual | Y |

Design Fundamentals: Campus Wireless LAN

The campus WLAN provides ubiquitous data and voice connectivity for employees, wireless Internet access for guests, and connectivity for IoT
devices connect to the network every year, ranging from high-performance client devices to low-bandwidth IoT devices.

Cisco wireless solutions are resilient, have the integrated security organizations need, and employ adaptive and insightful intelligence providing u
6 (802.11ax) standard and are ready for the growing user expectations, IoT devices and next gen cloud-driven applications. With the ability to ha
provide a secure, reliable high quality wireless experience for all networks.

Figure 21. Cisco next-generation wireless stack

Regardless of their location within the organization—on large campuses or at remote sites—wireless users have the same experience when co
services.

Infrastructure

The next-generation wireless stack is built around these main hardware and software components:

- Cisco Catalyst 9800 Series WLAN controllers (including appliances, virtual, and embedded)
- Cisco Catalyst 9100 Wi-Fi 6 APs
- Cisco DNA Center (assurance and automation)
- Cisco Prime Infrastructure (additional automation for more complex deployments)
- Cisco DNA Spaces

Cisco Catalyst 9800 Series wireless controllers

Cisco Catalyst 9800 Series wireless controllers combine RF excellence with Cisco IOS-XE benefits. These highly reliable and highly secure controllers are ready to deplo
dedicated appliance.

Cisco Catalyst 9800 Series wireless controllers are built on the three pillars of network excellence—always on, secure, and intelligent—which strengthen the network by

- **Always on**—Seamless software updates enable faster resolution of critical issues, introduction of new APs with zero downtime, and flexib
services, and clients always on, even in unplanned events.
- **Secure**—Secure air, devices, and users with Cisco Catalyst 9800 Series wireless controllers. Wireless infrastructure becomes the strongest
verification, and hardware authenticity.
- **Intelligent**—Cisco Catalyst 9800 Series wireless controllers are built on the modular Cisco IOS XE operating system, which offers a rich s
the health of your network and clients. When paired with Cisco DNA, your network works for you. Whether it's providing you with enhance

Cisco WLAN controllers are responsible for system-wide WLAN functions, such as security policies, intrusion prevention, RF management,
Cisco WLAN controllers provide the control, scalability, security, and reliability that network managers need to build secure, scalable wireles

The following table summarizes the Cisco WLAN controllers referenced within this guide.

**Table 2.** WLAN controller platforms

| Platform | Deployment Mode | Preferred Topology | Maximum APs | Maximum Clients |
|---|---|---|---|---|
| Cisco Catalyst 9800-80 | Centralized, FlexConnect, or SD-Access | Large Campus | 6,000 | 64,000 |

| | | | | | |
|---|---|---|---|---|---|
| Cisco Catalyst 9800-40 | Centralized, FlexConnect, or SD-Access | Medium Campus | 2,000 | 32,000 | Up to 100 Gbps |
| Cisco Catalyst 9800-L | Centralized, FlexConnect, or SD-Access | Small Campus / Remote Site | 250 | 5,000 | Up to 10 Gbps |
| Cisco Catalyst 9800-L with Performance License | Centralized, FlexConnect, or SD-Access | Small Campus / Remote Site | 500 | 10,000 | Up to 10 Gbps |
| Cisco Catalyst 9800 embedded on Cisco Catalyst 9000 Series Switches | SD-Access | SD-Access Small Distributed Site | 200 | 4,000 | — |

| | | | | |
|---|---|---|---|---|
| Cisco Catalyst 9800 Embedded on Catalyst 9100 Series Access Points (EWC) | Local Switching | Small Remote Site | 100 | 2,000 |
| Cisco Catalyst 9800-CL for Public Cloud | FlexConnect with Local Switching | Virtual Controller for Small Remote Sites | 1,000, 3,000, or 6,000 | 10,000, 32,000, or 64,000 |
| Cisco Catalyst 9800-CL for Private Cloud | Centralized, | Virtual controller for Small, Medium, or Large Sites | 1,000, | 10,000, |

| | | | |
|---|---|---|---|
| | FlexConnect, | 3,000 (central), or | 32,000 (central |
| | or SD-Access | 6,000 (FlexConnect) | 64,000 (FlexC |

Additional scale numbers, including maximum Site Tags, Flex APs per site, Policy Tags, RF tags, RF Profiles, Policy Profiles, and Flex Profiles controller platforms.

Because software license flexibility allows you to add additional APs when requirements of an organization change, you can choose the controlle when you need them.

Cisco Catalyst 9800 Series configuration model

The Cisco Catalyst 9800 Series wireless controller configuration data model is based on design principles of reusability, simplified provisioning, requirements. The configuration model maps APs to three types of tags - policy tags, site tags, and RF tags.

Figure 22. Cisco Catalyst 9800 Series configuration model

Wireless clients and APs derive their configurations from the profiles contained within the tags. The properties of a tag are defined by the policie themselves. Profiles are reusable entities that can be used across tags.

Policy tags

Policy tags define the broadcast domain (list of WLANs to be broadcast) within the policies of the respective SSIDs. For ease of deployment, tag each with their respective attributes shown in the figure below.

Figure 23. Components of a policy tag

Profiles may include additional components, not listed in the figure above.

Site tags

Site tags define the properties of the central and remote sites. They also define the roaming domain for Cisco FlexConnect APs in a Cisco Fle
shown in the figure below.

Figure 24. Components of a site tag

Profiles may include additional components, not listed in the figure above.

RF tags

RF tags define the properties of the group of APs. RF tags are associated with a 2.4 GHz RF Profile and a 5 GHz RF Profile - with their respecti
the figure below.

Figure 25. Components of a RF Tag

Profiles may include additional components, not listed in the figure above.

Cisco Catalyst 9800 Series wireless controller configuration can be managed using Cisco DNA Center, NETCONF/YANG, Cisco Prime Infrastru
line interface (CLI).

## Cisco Catalyst 9100 Series APs

Cisco Catalyst 9100 Series APs can handle the challenges of the next-generation network. Going beyond the Wi-Fi 6 (802.11ax) standard, Cisco Catalyst 9100 Series APs

- **Wi-Fi 6 and beyond—**Wi-Fi 6 reduces latency and increases capacity for demanding applications on more devices. Cisco improves on it w Center with deep analysis.
- **Addresses IoT expansion—**The Cisco Catalyst 9100 Series offers multilingual support and application hosting of IoT protocols. In additio stringent security.
- **Investment protection with multigigabit—**The Cisco Catalyst 9100 Series supports NBASE-T and IEEE 802.3bz Ethernet compatibility or 6 cables to achieve speeds up to 10 Gbps.
- **Available with embedded control—**You can choose an option that is easy to deploy and manage and doesn't require a physical appliance right into the access point.

The following table summarizes the APs discussed within this guide.

**Table 3.** Cisco Aironet APs

| | Cisco Catalyst 9115AX | Cisco Catalyst 9117AX | Cisco Catalyst 9120AX | Cisco Catal 9130AX |
|---|---|---|---|---|
| Best for | Small to medium deployments | Small to medium deployments | Mission critical, high density, large size networks | Best in clas |

| | | | | |
|---|---|---|---|---|
| Features | Wi-Fi 6 (802.11ax), OFDMA, Uplink/Downlink MU-MIMO, BSS Coloring, Target Wake Time (TWT), Apple Features | Wi-Fi 6 (802.11ax), OFDMA, MU-MIMO, Target Wake Time (TWT), Apple Features | Wi-Fi 6 (802.11ax), Cisco RF ASIC, Uplink/Downlink OFDMA, MU-MIMO, BSS Coloring, Target Wake Time (TWT), Intelligent Capture, Container support for applications, Apple Features | Wi-Fi 6 (802.1 Capture, Conta |

| | | | | |
|---|---|---|---|---|
| Radios | Three radios: 2.4 GHz (4x4), 5 GHz (4x4), and BLE | Three radios: 2.4 GHz (4x4), 5 GHz (8x8), and BLE | Four radios: 2.4 GHz (4x4), 5 GHz (4x4), Cisco RF ASIC, and BLE/IoT* | Four radios BLE/IoT* |
| Antennas | Internal and external | Internal | Internal and external | Internal and |
| Support for Cisco Catalyst 9800 Embedded (EWC) | Yes | Yes | Yes | Yes |
| Multigigabit Ethernet Support | Yes | Yes | Yes | Yes |
| HDX Support | No | No | Yes | Yes |
| Cisco CleanAir Technology | No | No | Yes | Yes |
| Flexible Radio Assignment | No | No | Yes | Yes |
| Combined Data Rate | Up to 5 Gbps | Up to 5 Gbps | Up to 5 Gbps | Up to 5 Gbps |

* Radio available for future use

Support for two key technologies differentiates the APs selected for deployment in the campus WLAN:

- **802.11ax (Wi-Fi 6)**—The IEEE 802.11ax (Wi-Fi 6) specification provides for significant enhancements to wireless networking performan the following:
  - Higher capacity: Attach more devices than under previous standards through features such as orthogonal frequency-division multiple acces communicated only "one at a time".
  - Improved power efficiency: Using target wake time (TWT), client devices that support the Wi-Fi 6 standard may consume less power. This makes it the ideal standard.
  - Reduced data latency by optimizing packet scheduling, which is ideal for voice, video and gaming applications.

- Greater IoT coverage by bringing the benefits of Wi-Fi 6 to the 2.4- GHz band.
- Increased speed: Gain an increase in average throughput in congested wireless environments.
- Improved security: WPA3 is certified with Wi-Fi 6 and provides a greater value proposition than WPA2 for enterprise Wi-Fi networks. It offe

superior data reliability for sensitive information with 192-bit encryption.

- **Cisco RF ASIC**—The custom Cisco RF ASIC, available within the Cisco Catalyst 9120AX and 9130AX Series APs, provides enhanced off-c

system (WIPS) and DFS detection. This silicon-level intelligence creates a self-healing, self-optimizing wireless network that mitigates the impa

Cisco DNA Spaces

Cisco DNA Spaces provides organizations with rich location-based wireless services, including location analytics, business, insights, customer e

Catalyst and Cisco Meraki wireless APs, lets your enterprise see activity at its properties, act on these insights and extend platform capabilities vi

With Cisco DNA Spaces you gain the following benefits:

- **Simplification**: A single, unified platform for accessing location products and apps and for normalizing data to create meaningful insights
- **Cloud first, scalable**: A cloud-first software-as-a-service (SaaS) approach that enables presence and location connection to the cloud across th

base

- **Standardization**: Compatibility and interoperability across all Cisco wireless—Cisco Aironet, Cisco Catalyst, and Cisco

Meraki

- **Support**: 24x7 monitoring and service-level agreements (SLAs) for end-to-end reliability
- **Low touch**: No need to upgrade your underlying network infrastructure to activate service

Cisco DNA Spaces takes the wireless network beyond connectivity to drive digitization in three easy steps: See, Act, and

Extend.

Figure 26. Cisco DNA Spaces

Now you can see what's happening at your properties, act on this knowledge through digitization toolkits, and extend platform capabilities by ecosystem.

Cisco DNA Spaces provides support for all wireless deployment modes.

Figure 27. Cisco DNA Spaces network architectures

An on premises deployment of Cisco DNA Spaces is required for the following:

- **Hyperlocation**—To use the Cisco Aironet 4800 Series or 3700 Series APs with a hyperlocation antenna, or to use fast path on all APs on a location calculations.
- **Integration with Cisco DNA Center or Prime Infrastructure**—To provide location data to Cisco DNA Center or Prime Infrastructure, a currently required.

Wireless design models

This guide describes the following design models and their recommended use:

- Centralized (local-mode) design model

- Cisco FlexConnect design model
- Cisco SD-Access Wireless design model
- Cisco Catalyst 9800 Embedded on Catalyst 9100 Series APs (EWC) design model

Centralized (local-mode) design model

A centralized design model, also known as a local-mode design model, is recommended primarily for large site deployments. The benefits of a ce
WLAN controller and APs are both located within the same site.

You can connect the WLAN controller to a data center services block, a separate services block off of the campus core, or a LAN distribution lay
and the AP. This has the advantage of decoupling the subnet on which the wireless clients terminate from the AP; requiring the availability of the

Figure 28. Local-mode design model

A centralized architecture uses the controller as a single point for managing Layer 2 security and wireless network policies. It also enables service

coordinated fashion.

The local-mode design model meets the following organization demands:

- **Seamless mobility**—Enables fast roaming across the campus, so that users remain connected to their session even while walking between subnets
- **Ability to support rich media**—Enhances robustness of voice with call admission control and multicast with Cisco VideoStream technology
- **Centralized policy**—Enables intelligent inspection through the use of firewalls, as well as application inspection, network access control, traffic classification

If *any* of the following are true at a site, you should consider deploying a controller locally at the site:

- The site has a data center.
- The site has a LAN distribution layer.
- The site has more than 100 APs.
- The site has a WAN latency greater than 100ms round-trip to a proposed shared controller.

The recommended platforms for large centralized (local-mode) designs are the Cisco Catalyst 9800-80 and 9800-40 WLAN controllers, becau 9800-CL virtual form factor deployed within a private cloud is another alternative and includes the same feature set as the Cisco Catalyst 980

Cisco FlexConnect design model

Cisco FlexConnect is a wireless solution primarily for deployments that consist of multiple small remote sites (branches) connected into a cen through the WAN, without deploying a controller in each remote site.

Cisco APs operating in Cisco FlexConnect mode can switch client data traffic out their local wired interface and can use 802.1Q trunks in ord referred to as Cisco FlexConnect local switching and is the mode of operation described in this guide.

Figure 29. Cisco FlexConnect design model

Cisco FlexConnect can also tunnel traffic back to the centralized controller, which can be used for wireless guest access. You can use a shared co
FlexConnect.

In a shared controller model, both local-mode and Cisco FlexConnect configured APs share a common controller. A shared controller architectur
Catalyst 9800-80, 9800-40, 9800-L Series appliances and the Cisco Catalyst 9800-CL for private cloud wireless controllers.

You may be able to use a shared deployment if you meet all the following requirements:

- You have an existing local-mode controller pair at the same site as your WAN aggregation.
- The controller pair has enough additional capacity to support the Cisco FlexConnect APs.
- The number of site tags with Cisco FlexConnect profiles required matches the capabilities of the controller pair.

If you don't meet the requirements for a shared controller, you can deploy dedicated Cisco Catalyst 9800-80, 9800-40, or 9800-L Series wireless
typically locally terminated in a Cisco FlexConnect deployment. The Cisco Catalyst 9800-CL deployed within a public cloud only supports Cisc
wireless traffic, although at lower scale (up to 1.5 Gbps) than a dedicated controller appliance.

For highest resiliency, deploy a pair of controllers in HA SSO configuration. Alternatively, you can deploy N+1 high availability in order to prov
WLC fails (the CAPWAP tunnel goes down), the AP establishes connectivity to the secondary WLC – potentially deployed at a different regiona

If all of the following are true at a site, you should consider deploying Cisco FlexConnect at the site:

- The site LAN is a single access-layer switch or switch stack.
- The site has fewer than 50 APs.
- The site is one of many small remote sites connected to a central location
- The site has a WAN latency less than 100ms round-trip to the shared controller.

Cisco SD-Access Wireless design model

Cisco SD-Access Wireless is the fabric-enabled wireless solution that, unlike any alternative solution, fully integrates with a wired Cisco SD- this model, the fabric WLCs communicate wireless client information to the fabric control plane, and the fabric APs encapsulate traffic into th

**Note:** SD-Access Wireless control plane traffic is passed to the WLC, while data plane traffic is passed directly into the fabric. The distrib easily stretch the Layer-2 domain.

Figure 30. Cisco SD-Access wireless design model

Requirements for deploying Cisco SD-Access Wireless:

- Cisco SD-Access wired fabric deployment
- APs with fabric mode support directly connected to Cisco SD-Access fabric edge nodes
- WLC with fabric mode control plane support
- 20ms or less latency between the fabric APs and the fabric WLC
- Cisco SD-Access Wireless design model

Cisco Catalyst 9800 Embedded on Catalyst 9100 Series APs (EWC) wireless design model

The Cisco EWC is a Wi-Fi solution using a Cisco Catalyst 9800 Series Wireless Controller embedded into the Cisco Catalyst 9100 Series APs. T
controller does not need to be deployed.

Figure 31. Cisco EWC wireless design model

The Cisco EWC platform provides the following benefits:

- High availability with active and standby controllers running simultaneously on two Cisco Catalyst 9100 Series APs (configuration synchr not HA SSO)
- Software maintenance updates (SMUs) providing hot patching of the controller, AP device packs, and AP service packs supported, like sta controllers
- Cisco DNA Center support for Plug and Play, Automation, and Assurance, including Intelligent Capture (similar to other deployment models)
- Advanced RF features such as Flexible Radio Assignment (FRA) and Cisco CleanAir technology (similar to other deployment models)
- Automatic configuration of wireless best practices from more than 10 years of experience with large and medium-scale implementations

If the following are true, you should consider deploying the EWC at the site:

- Single site or multisite enterprise locations with up to 100 APs and 2,000 clients per site for Cisco Catalyst 9120AX or 9130AX Series run 9117AX Series running EWC.
- Guest Anchor is not required (currently not supported on the EWC).
- Layer 2 roaming only, without mobility groups.

**Note:** Cisco 802.11ac Wave 2 APs can join a Cisco EWC network and service clients, but Cisco 802.11ac Wave 2 APs cannot run the EWC function.

Design Options: Campus Wireless LAN

AP site tag considerations

Cisco Catalyst 9800 Series wireless LAN controllers have a multi-process architecture. Multiple wireless network controller processes (WNC platform to platform.

APs (and wireless clients) are load balanced across the WNCd instances for better scale and performance. In recent software releases, APs ar WNCd instances in a round robin fashion.

Roaming and fast roaming work across site tags. However, 802.11k assisted roaming, 802.11v BSS transition, coverage hole detection (CHD and not use the default site tag. For best performance, use a custom site tag to group APs within a roaming domain. Also, a best practice is to

The following are recommendations based on specific deployments:

- If the deployment has a building with more than 400 APs, consider splitting the building into two parts from site tag perspective. Each par 400 APs.

Figure 32. Single building with more than 400 APs

- If the deployment has a roaming domain that spans across multiple buildings, with more than 400 APs, consider configuring a Site Tag per building.

Figure 33. Multiple buildings with more than 400 APs

- If the deployment has multiple buildings, with less than 400 APs, consider configuring a single custom site tag. Don't use the default site tag.

Figure 34. Multiple buildings with less than 400 APs

- When deploying Cisco FlexConnect, set the site tag to be a non-Local Site within the Cisco Catalyst 9800 configuration. When the Local S
wireless controllers.

Figure 35. Site Tags for Cisco FlexConnect APs

There is a limit of 100 APs per Cisco FlexConnect site tag for seamless roaming. Roaming across site tags for Cisco FlexConnect APs results in reauthentication.

## High availability

As more devices with critical functions move to the wireless medium, high availability of the wireless infrastructure is becoming increasingly imp negative impacts of wireless network outages are just as impactful as outages of the wired network. Implementing high availability within the wir availability. This section discusses high availability specific to the implementation of wireless controller platforms. Platform-level redundancy re

Designing for high availability must also consider the entire lifecycle of the deployment, including the need for updates and upgrades on the netw fixes and updates, and AP device packs for support for new AP models

The methods of high availability discussed within this design guide, available with releases of Cisco IOS-XE 17.1 and higher, are as follows:

- High availability SSO
- N+1 high availability
- WLAN controller link aggregation
- Wireless controller patches using software maintenance updates (SMUs)
- AP patches using AP service packs (APSPs)
- Support for new AP models using AP device packs (APDPs)

### High availability stateful switchover (HA SSO)

Cisco wireless LAN controllers support AP stateful switchover and client stateful switchover. These two features are collectively referred to as H the wireless network with controller recovery times in the sub-second range during a WLAN controller disruption.

The configuration and software upgrades of the primary WLAN controller are automatically synchronized to the resilient standby WLAN controller.

### N+1 high availability

You can use the N+1 HA architecture in order to provide redundancy for WLAN controllers within a single site or across geographically separate for remote branches. You can use a single backup WLAN controller in order to provide backup for multiple primary WLAN controllers. HA SS

With N+1 HA, WLAN controllers are independent of each other and do not share configuration or IP addresses on any of their interfaces. Each W across the WAN link.

It is recommended (but not required) that you run the same software version across WLCs used for N+1 HA, in order to reduce downtime as the A

always connect first to the backup controller, even if they must push out low priority APs. When a primary WLC resumes operation, the APs

WLAN controller link
aggregation

Cisco wireless controller appliances have multiple physical Ethernet ports. In typical deployments, one or more WLANs/service set identifier and terminated on the physical ports. With the use of a single physical port per WLAN, the throughput of each WLAN is limited to the throu

When LAG is enabled, the wireless controller dynamically manages port redundancy and load-balances APs transparently. If any of the contr remain connected to the network, and wireless clients continue to send and receive data.

Preferred redundancy – Cisco Catalyst 9800 HA SSO pair connected to redundant single logical switch

LAG requires an EtherChannel Port Group to be configured on the attached Cisco Catalyst switch. The EtherChannel port group can be confi group is referred to as a Multichassis EtherChannel (MEC). The EtherChannel is configured using 802.1Q trunk encapsulation to carry multip

The following figure shows an example of wireless controller link aggregation in a high availability configuration to a Cisco StackWise Virtu distribution switch stack.

Figure 36. Preferred redundancy for controller HA SSO pair

Spreading the ports from the active and standby WLCs across both switches within the Cisco StackWise Virtual pair is the recommended des failure) operation, because both the active and standby WLCs have ports connected to both switches. This design also avoids a switchover fr connected to the active WLC is reduced by half. You choose a switching platform with appropriate resources to support ARP and MAC addre

**Note:** Catalyst 9800 wireless controllers support PagP and LACP as of IOS XE 17.1 and higher.

Preferred redundancy - Single Cisco Catalyst 9800 controller connected to redundant single logical switch

If you are only connecting a single Cisco Catalyst 9800 controller to the wired LAN, such as for an N+1 controller deployment, connect the singl
highly redundant modular chassis.

Figure 37. Preferred redundancy for single controller

The trunk configuration and switching platform choices from the previous design also apply here.

Wireless controller patches using software maintenance updates (SMUs)

An SMU is a software package that can be installed on a wireless controller to provide a patch fix for bugs or security resolution to an already rel
and cold patching.

A hot patch does not need a system reload - meaning that clients and APs will not be affected when applying the hot patch. When the wireless co
standby controllers.

A cold patch does require a system reload. However, in an HA SSO pair, the system will first install the SMU on the standby controller and reloa
controller. The new active controller takes over all AP and client sessions. Then, the new standby controller (previously the active controller) is u

**Note:** SMUs are only released on long-lived Cisco IOS-XE extended maintenance releases.

AP patches using Access Point Service Packs (APSPs)

Cisco Catalyst 9800 Series wireless controllers support rolling out critical AP bug fixes using APSPs. APSP rollout can be based upon sites, with
affected AP models.

With rolling AP upgrade, AP upgrades can be staggered to ensure RF coverage to clients throughout the upgrade process. Rolling updates suppo
25%, with the default being 15%) the wireless controller auto-selects candidate APs to be upgraded in each iteration. Clients from the candidate A
Clients that do not honor this setting are de-authenticated before the AP is reloaded.

Support for new AP models using Access Point Device Packs (APDPs)

Beginning with Cisco IOS-XE release 16.11, Cisco Catalyst 9800 Series wireless controllers provide a way to support new AP models using A
are hot patches, they do not require a reload and require no downtime of the wireless controller.

The following table summarizes high availability support with the various controllers.

**Table 4.** High availability feature support

| Platform | HA SSO | N+1 HA | Stack Redundancy | LAG |
|---|---|---|---|---|
| Cisco Catalyst 9800-80 | Yes | Yes | — | Yes |
| Cisco Catalyst 9800-40 | Yes | Yes | — | Yes |
| Cisco Catalyst 9800-L | Yes | Yes | — | Yes |
| Cisco Catalyst 9800 embedded on Cisco Catalyst 9000 Series Switches | No | No | Yes | — |
| Cisco Catalyst 9800 Embedded on Catalyst 9100 Series Access Points (EWC) | Active/standby control plane with local switching data plane | No | — | — |
| Cisco Catalyst 9800-CL for | No | Yes | — | — |
| Public Cloud | | | | |
| Cisco Catalyst 9800-CL for Private Cloud | Yes | Yes | — | Via hypervisor |

Multicast support

Video and voice applications continue to grow as smartphones, tablets, and PCs are added to wireless networks in all aspects of our daily life.
enable the efficient delivery of certain one-to-many applications, such as video and push-to-talk group communications. By extending the sup

The campus WLAN supports multicast transmission for the onsite controller using multicast-multicast mode, which uses a multicast IP addre
multicast mode is supported by using the Cisco Catalyst 9800 Series WLAN Controllers.

Remote sites that use Cisco FlexConnect local switching mode can also benefit from the use of multicast-based applications. Multicast in rem
multicast streams are serviced directly over the WAN or LAN network with no additional overhead being placed on the WLAN controller.

Guest wireless

Using the existing campus wired and wireless infrastructure for guest access provides a convenient, cost-effective way to offer Internet access

deployment.

Centralized deployments with guest wireless

For centralized (local-mode) deployments, the traditional method of providing wireless guest access is to implement a dedicated guest anchor con
tunneled data connection). The guest network is only able to reach the Internet and the internal DHCP and DNS servers (unless separate DHCP a

Figure 38. Traditional guest wireless anchor controller design

Additional security functionality besides firewalling may be applied within the Internet Edge / DMZ. This additional functionality is not shown i
figure above.

Cisco Catalyst 9800 Series wireless controllers support secure mobility – meaning the anchor tunnel uses CAPWAP encapsulation, as opposed to
and anchor wireless controllers.

Cisco FlexConnect guest deployments

For Cisco FlexConnect guest deployments, the guest WLAN/SSID can be centrally switched and anchored through a dedicated guest controll segment.

Figure 39. FlexConnect with centrally-switched guest wireless access

Alternatively, the guest WLAN/SSID can be locally switched to a VLAN within the branch which provides direct Internet access (DIA).

Figure 40. FlexConnect with locally-switched guest wireless access

Additional security functionality besides firewalling may be applied within the branch for direct Internet access. This is not shown in the figure above.

Cisco SD-Access deployments with guest wireless

For fabric wireless guest access services to the Internet, you can separate wireless guests from other network services by creating a dedicated virt type of deployment does not require any dedicated guest anchor controller to be deployed. Alternatively, guest traffic can be encapsulated right f

For more information, see the Software-Defined-Access Solution Design Guide, at https://cs.co/sda-sdg.

Cisco Catalyst 9100 Series EWC deployments guest wireless

Cisco Catalyst 9100 Series EWC deployments do not support a dedicated guest anchor wireless controller. As with FlexConnect locally switched direct Internet access (DIA).

All guest wireless deployments—authentication and access control

Regardless of the wireless deployment option, the wireless guest network typically provides the following functionality:

- Provides Internet access to guests through an open wireless SSID, with web authentication access control.
- Supports the creation of temporary authentication credentials for each guest by an authorized internal user.
- Keeps traffic on the guest network separate from the internal network in order to prevent a guest from accessing internal network resources.

Most organizations' IT departments choose to have guest wireless users authenticate first, before allowing access to the Internet. This step is som organization's IT department typically has no control over the hardware or software capabilities of guest wireless devices, the authentication and considered for any policy decision. A typical way of implementing guest user authentication is through the guest user's web browser, a method k browser, to a URL located somewhere within the Internet. The browser session is re-directed to a web portal that contains a login page that reque is also known as a captive portal.

There are multiple ways of authenticating guests on WLANs, such as the following:

- **Local web authentication**—With this method, the web session of the guest device is redirected by the guest wireless controller to a web porta

The advantage of this option is that the entire management of guest wireless access is confined to the guest wireless controller within the DMZ. T

- **Central web authentication**—With this method, the web session of the guest device is redirected by the guest wireless controller to an extern

(AAA) server. Cisco Identity Services Engine (ISE) can provide both the external web portal and AAA server functionality. By positioning the

access without having to create a separate login page on each guest wireless controller. By moving the guest credential database and guest sp
on each guest wireless controller.

- **Cisco DNA Spaces-based guest onboarding**—Cisco DNA Spaces-based guest-onboarding is often implemented by organizations who wi
wireless network and access the Internet from the venue by logging in using their existing social media credentials. The venue owner may als
venue location.

Multicast domain name services and Bonjour gateway

Bonjour is Apple's zero-configuration protocol for advertising, discovering, and connecting to network services such as file sharing, print sha
to share network services. Although this approach works well in home networks, a limitation of link-local multicasting is that these network s
different classes of devices, including corporate devices, employee devices, personal devices, and guest devices (as well as quarantine WLAN

To address this limitation and to meet user demand for BYOD Apple devices within the enterprise, Cisco developed the Bonjour Gateway fea
Gateway feature for WLCs solves the Layer 2 domain limitation for Bonjour by allowing the WLC to snoop, cache, and proxy-respond to Bo
certain Bonjour services will be permitted in specific Layer 2 domains.

The Bonjour protocol uses mDNS queries. These queries are sent over UDP port 5353 to these reserved group
addresses:

- IPv4 Group Address: `224.0.0.251`
- IPv6 Group Address:

`FF02::FB`

It is significant to highlight that mDNS addresses used by Bonjour are link-local multicast addresses and are only forwarded within the local I
because the time-to-live (TTL) of these packets is set to the value 1.

This link-local multicast limitation of Bonjour mDNS is illustrated in the following figure.

Figure 41. Bonjour deployment limitation in enterprise networks

The Bonjour Gateway feature (the mDNS gateway feature most often enabled for Bonjour) snoops and caches all Bonjour service advertisements
Bonjour queries.

Bonjour gateway service policy deployment options

A key functional advantage of the Bonjour gateway is that it can be configured to selectively reply to Bonjour service requests, thus allowing for
include the VLAN to which the WLAN is terminated). Policy Profiles and WLAN Profiles (which include the WLAN/SSID name) are then attac

Since the Cisco Catalyst 9800 Series wireless controller will respond and advertise for services cached when acting as a Bonjour gateway, it must
that are coming out from the controller acting as mDNS Gateway.

Cisco Application Visibility and Control

The Cisco Application Visibility and Control (AVC) solution —already supported on Cisco routing platforms such as the Cisco ASR 1000 and C
Cisco Catalyst 9800 Series WLCs.

The Cisco AVC feature set increases the visibility, productivity, and manageability of the wired and wireless network. Additionally, the support o
QoS solutions end-to-end.

AVC includes these components:

- Next-generation deep packet inspection (DPI) technology called Next Generation Network-Based Application Recognition (NBAR2), which a
that includes support of stateful L4-L7 classification.
- Ability to remark applications using DSCP policies, which you can then use to prioritize or de-prioritize applications for QoS treatment over b
wireless networks.
- A template for Cisco Flexible NetFlow v9 to select and export data (local-mode only) of interest to Cisco PI or a third-party NetFlow collector
compliance purposes.

Cisco AVC on the Cisco Catalyst 9800 Series wireless LAN controllers inherits NBAR2 from Cisco IOS-XE that provides DPI technology in orc
configuring an access list based on the TCP or UDP port number(s) to positively identify an application. In fact, as applications have matured —p
carry thousands of potential applications within it and in today's networks seems to function more as a transport protocol, rather than as the OSI a

After the NBAR engine recognizes applications by their discrete protocol signatures, it registers this information in a Common Flow Table so tha
this classification result.

Cisco AVC provides:

- Application Visibility on the Cisco Catalyst 9800 Series WLC by enabling Application Visibility for any WLAN wireless policy profile config
can view Application Visibility on the WLC at an overall network level, per WLAN or per client.
- Application Control on the Cisco Catalyst 9800 Series WLC by creating an AVC-based QoS policy and attaching it to a policy profile attached
mark (with DSCP), police (to a rate), or drop.

Key business use cases for Cisco AVC include:

- **Classifying and marking wireless mobile device applications**—Identifying and differentiating real-time voice, video, or business-critical ap
specific application traffic.

- **Capacity planning and trending**—Baselining the network to gain a clearer understanding of what applications are consuming bandwidth infrastructure upgrades.

Cisco Catalyst 9800 advanced wireless intrusion prevention system (wIPS)

The Cisco Catalyst 9800 advanced wIPS architecture—available in Cisco IOS-XE 17.1 and higher—provides the following benefits:

- Low footprint solution
- Ease of Cisco DNA licensing (requires Cisco DNA Advantage licensing)
- Alarm consolidation

Figure 42. Cisco Catalyst 9800 wIPS architecture

The basic system components for a Cisco Catalyst 9800 adaptive wIPS system include:

- Cisco 802.11ax or 802.11ac Wave 2 APs (local-mode, Cisco FlexConnect mode, or monitor mode)
- Cisco Catalyst 9800 Series Wireless controllers (local-mode, Cisco FlexConnect, or fabric deployments)
- Cisco DNA Center

**Table 5.** Alarms supported in Cisco IOS-XE 17.1

| Alarm ID | Alarm |
|---|---|
| 10001 | DoS: Authentication Flood Alarm |

| | | |
|---|---|---|
| 10002 | DoS: Association Request Alarm | |
| 10003 | DoS: Broadcast Probe Flood Alarm | |
| 10004 | DoS: Dissociation Flood Alarm | |
| 10005 | DoS: Broadcast Dis-Association Alarm | |
| 10006 | DoS: De-Authentication Flood Alarm | |
| 10007 | DOS: Broadcast De-authentication Alarm | |
| 10008 | DOS: EAPOL-Logoff Attack Alarm | |

Rogue device detection

An organization can regard any device unmanaged by the organization that shares the organization's RF spectrum as a rogue device. A rogue dev following scenarios:

- Rogue AP with the same SSID as your network (often called a *honeypot*)
- Rogue AP device also on the wired network
- Ad-hoc rogue devices
- Rogue devices set up for malicious intent by someone outside the organization

There are three main phases of rogue device management in the Cisco Catalyst wireless solution:

- **Detection**—Managed using RRM scanning in order to detect the presence of rogue devices.
- **Classification**—Managed using rogue location discovery protocol (RLDP) and switch port tracing in order to identify whether the rogue devic characteristics of a device.
- **Mitigation**—Managed using switch port tracing and disablement, rogue device location, and rogue device containment in order to track down rogue devices.

Cisco DNA Center release 1.3.1.3 and higher supports the Rogue Management application within Cisco DNA Assurance. The Rogue Manageme within Cisco DNA Center.

For additional information about a range WLAN controller versions, visit cisco.com and search for "Wireless Rogue Management."

Radio Resource Management (RRM)

To optimize efficiency, RRM software embedded in the Cisco Wireless LAN Controller acts as a manager to constantly monitor over-the-air met transmitted. It measures:

- **Signal**—Your own APs belonging to the same RF network.
- **Interference**—Other 802.11 devices operating nearby that can be heard by your network.
- **Noise**—Any energy in the RF spectrum that cannot be demodulated as 802.11 protocol.
- **Load**—Instantaneous user load on the network.
- **Coverage**—The RSSI and signal-to-noise ratio estimated by the system for clients attached to your network.

Using this information, RRM can periodically reconfigure the 802.11 RF network for best efficiency. To do this, RRM performs these functions:

- **RRM data collection**—Collecting the metrics
- **Transmit Power Control (TPC) algorithm**—Adjusting for optimal power levels
- **Dynamic channel assignment (DCA)**—Ensuring that channel assignments do not overlap
- **Cisco Flexible Radio Assignment (FRA)**—Determines the role of the flexible radio for APs with that flexible radio capability
- **Coverage Hole Detection and Mitigation (CHDM) algorithm**—Ensuring that you have adequate coverage and detecting clients that may coverage hole

RRM automatically detects and configures new Cisco WLCs and Cisco Catalyst APs as they are added to the network. It then automatically a coverage and capacity.

For more detailed information about what RRM does and how it takes its measurements, see the Radio Resource Management White Paper on cisco.co

Transmit power control

The Cisco WLC dynamically controls AP transmit power based on real-time WLAN conditions. Cisco Catalyst 9800 Series WLCs support T for use in most deployments.

Overriding the TPC algorithm with minimum and maximum transmit power settings

The TPC algorithm balances RF power in many diverse RF environments. However, it is possible that automatic power control will not be ab must be mounted in a central hallway, placing the APs close together but requiring coverage out to the edge of the building.

In these scenarios, you can configure maximum and minimum transmit power limits to override TPC recommendations. The maximum and m apply to all APs attached to the specific controller.

If you configure a minimum transmit power, RRM does not allow any AP attached to the controller to go below this transmit power level, reg then no AP will transmit below 11 dBm, unless the AP is configured manually and no longer under control of RRM.

Dynamic Channel Assignment

The 802.11 specification defines multiple channels for operation. The channels are essentially different frequency ranges that are non-overlap from another lane on the same highway. If the lanes overlap each other (or worse, merge into a single lane), then the highway slows to a craw

Channels in an RF network work similarly. However, there is an additional consideration of power, equivalent to making lane wider or narrower installation. Secondly, DCA assigns channels to APs that do not conflict with channels already assigned. For a given AP, potential throughput is possible, based on over-the-air observations.

After all APs have been installed, it is a best practice to then calibrate DCA by invoking the RRM start-up mode. The RRM startup mode is invo conditions:

- In a single-controller environment, the RRM startup mode is invoked after a successful upgrade of the controller software; otherwise, it is man below).
- In a multiple-controller environment, the RRM startup mode is invoked after an RF Group leader has successfully upgraded the software; othe the CLI.

You can trigger RRM startup mode from CLI, using the following command:

```
ap dot11 {24ghz | 5ghz} rrm dca restart
```

RRM startup mode runs for 100 minutes (10 iterations at 10-minute intervals). The startup mode consists of 10 DCA runs with high sensitivity ar DCA continues to run at the interval and sensitivity as specified by the organization.

Cisco Flexible Radio Assignment

Cisco FRA is a feature that takes advantage of hardware choices available in the Cisco Catalyst 9100 Series APs. As described for band selection of 2.4 GHz radios and their limited channel selection options, which will cause interference issues. Cisco FRA measures this and identifies APs

Cisco FRA first identifies redundant APs and then manages the changing of the single XOR radio to another band. Cisco FRA relies on hardwar admins can use to manually select and configure redundant radios within the deployment.

Coverage Hole Detection and Mitigation algorithm

The RRM CHDM algorithm detects areas of weak radio coverage in a WLAN that are below the level needed for robust radio performance. This relocated AP.

If clients associated to an AP are detected at threshold levels lower than those specified in the RRM configuration, the AP sends a “coverage hole an area where clients are continually experiencing poor signal coverage without having a viable AP to which to roam. The controller discriminate power level for a specific AP that can improve the coverage. For clients that are making poor roaming decisions (referred to as *sticky clients*), the that new AP for an arbitrary reason.

Benefits of RRM

RRM produces a network with optimal capacity, performance, and reliability. It frees you from having to continually monitor the network for noi throughout the Cisco wireless network.

Band Select

Most consumer devices being released today operate in one or both of two frequency ranges, or, *bands*. Dual-band devices are quite common; ho

significantly, with 5 GHz having as much as 8 times the available bandwidth as 2.4 GHz. Even so, the 2.4 GHz physical properties allow a d

Band Select allows identification of dual-band clients and helps the devices make informed decisions about which frequency range and AP to probes. This system behavior encourages clients to use the available superior bandwidth in 5 GHz and increases the overall network capacity.

Organizations are advised to enable Band Select in all environments. For more information on configuring Band Select, visit cisco.com and search for Wi

Dynamic bandwidth selection (DBS)

With the introduction of 802.11n, 802.11ac Wave 1 and Wave 2, and 802.11ax, you can use multiple channels together as a single assignment However, to use these combined channels, an AP and a client must both support the capability.

Bonding channels—using multiple single channels to create a single super channel—has the advantage of providing more usable throughput t the overall number of non-interfering channels to use with DCA. This can result in aggressive channel reuse if there are enough APs (each or

Dynamic Bandwidth Selection works with the DCA algorithm to monitor the APs and the client types and capabilities using the APs. Based traffic that each AP uses.

DBS allows appropriately sized bandwidth to be used for the clients being served, avoids wasting multiple channels for devices that likely co run DCA in DBS mode.

For additional details, visit cisco.com and search for High Density Experience (HDX) Deployment Guide.

Cisco CleanAir

Cisco CleanAir is a purpose-built spectrum intelligence solution designed to proactively manage the non-Wi-Fi interference in the 2.4 and 5 G use different protocols but occupy the same frequencies required for operation of the WLAN.

Cisco CleanAir is an innovation available in Cisco Catalyst 9120AX and 9130AX APs, which include the Cisco RF ASIC. CleanAir is dedica appear as noise to a Wi-Fi chipset.

Cisco CleanAir technology was released in 2010 and has continuously adapted to keep pace with the market and changing nature of the WLA monitors the range of 20 MHz-160 MHz channels.

CleanAir can report analysis and findings through the WLAN controller. You can use certain Cisco DNA Spaces implementations and Cisco and troubleshooting.

At the controller level, you can use two mitigation strategies to help maintain your network and prevent outages associated with common non sources:

- **Persistent Interference Avoidance**—Allows the WLC to track and report non-Wi-Fi interferers to DCA. For instance, there may be a mi for the affected APs that will not be interfered with by this periodic interference source.
- **ED-RRM**—Helps mitigate disruptions from interference sources (perhaps a video camera) that use 100% of the available airtime when en become less busy. ED-RRM provides a safety net by doing two things:
  - Recognizing that something is not noise but instead is intentionally transmitting and interfering with the network operations.
  - Forcing the AP away from the problematic channel to a channel where operations can resume. The resolution is very fast acting (30 second channel just abandoned.

As a best practice, you should enable CleanAir, Persistent Device Avoidance, and ED-RRM.

For additional details, visit cisco.com and search for the Cisco CleanAir Technology: Intelligence in Action White Papers.

Secure WLANs

Wireless devices should connect to the network infrastructure securely where possible. In an enterprise environment, secure the WLANs by confi
modern wireless devices support WPA2. You should consider migrating to the newer WPA3 standard, which is supported by Cisco Catalyst 980

WPA3 is the latest version of Wi-Fi Protected Access (WPA), which is a suite of protocols and technologies that provide authentication and encry
by third parties. SAE employs a discrete logarithm cryptography to perform an efficient exchange in a way that performs mutual authentication u
possible passwords without further network interaction.

WPA3-Personal protects individual users better by using more robust password-based authentication making the brute-force dictionary attack mu
data networks.

Opportunistic Wireless Encryption (OWE) is an extension to IEEE 802.11 that provides encryption of the wireless medium. The purpose of OWE
to setup the wireless encryption. With OWE, the client and AP perform a Diffie-Hellman key exchange during the access procedure and use the r

The use of older security methods, such as WEP or WPA, is not recommended due to known security vulnerabilities. 802.1x authentication requi
accessing the wireless network.

Typically, the AAA server will implement the RADIUS protocol between itself and the WLC. Authentication of end-users is accomplished via a
the AAA server. Depending upon the capabilities of wireless device, the capabilities of the AAA server, and the security requirements of the org
authentication. EAP-TLS makes use of digital certificates for authentication.

It is highly recommended that you deploy redundant AAA servers for high availability in case one or more servers become temporarily unavailab
administrator to leverage existing AD credentials instead of duplicating them within the AAA server. This can also be extended to provide role-b
as opposed to the access granted employees. The use of an external directory or data store can also provide a single point for granting or revoking
policy-based rules for authorization to the network, such device type, time of day, location, etc., depending upon the capabilities of the AAA serv

The use of WPA2 with AES-CCMP encryption on the WLAN does not extend to management frames. Therefore, the optional use of protected m
robust management frames such as de-authentication and dissociation frames, preventing them from being spoofed. It should be noted that the be
client components.

In a home-office environment, it may be necessary to configure a WLAN to support WPA2 with pre-shared key (PSK). This is sometimes referre
access the WLAN. This may also be necessary in other environments if there is no end-user associated with a wireless device, the wireless devic
access the wireless infrastructure, it may be necessary to change the PSK if an employee who knows the PSK leaves the organization. Furthermo

The use of a dedicated, open WLAN is still common, but not ideal, for wireless guest access. Therefore, the configuration of an unsecure WLAN
needs only temporary wireless network connectivity. Typically, the guest WLAN is terminated outside the corporate firewall, which allows no ac
to authenticate before being allowed to access the Internet. Typically, a captive-portal model is used with WebAuth, in which guest web sessions

Administrative Access Control

It is recommended that you implement secure administrative access control to wireless infrastructure components in order to mitigate against una

centralized AAA server—such as Cisco ISE.

For a small number of network infrastructure devices, configuring individual local administrator accounts on each infrastructure device may b ability to audit who accessed a particular network device and potentially made configuration changes. When employees leave the organizatio needs to be revoked.

As the number of infrastructure devices within the network grows, the administrative burden of configuring individual local administrator acc centralized policy-based management and control. It is recommended that you deploy redundant AAA servers for high availability in case one local access via the console port, should all network access to the infrastructure device be lost.

The AAA server may itself reference an external directory or data store such as AD. This allows the network administrator to leverage existi of an external directory or data store can also provide a single point to grant or revoke credentials, not only for administrative access control t

Where possible, the selection of a strong password—consisting of a minimum length, and combination of letters, numbers, and/or special cha also be enforced. Successful and unsuccessful attempts should be logged either locally or to a central logging server. This helps mitigate aga supported, it is recommended you enforce them, with administrators having the minimum access level required for performing their respectiv

It may be advantageous to limit where access to the wireless infrastructure device is initiated from and what protocols are allowed. You can a from wireless client traffic. In such a deployment, an access-control list (ACL) deployed on the Layer 3 switch adjacent to the WLAN contro CPU ACL on the WLAN controller to filter management protocols. You can also disallow management of the WLAN controller via a wirele

Access to wireless infrastructure devices should be via secure protocols such as HTTPS and SSHv2 where possible. Access via non-encrypte SNMP, it is recommended that you enable SNMPv3 where possible. SNMPv2c relies on a shared community string that is sent in clear text a also provide encryption and data authentication services to SNMP traffic.

Controller dashboard best practices checklist

For convenience of network deployment engineers, a best practices checklist is available within the dashboard for WLAN controllers. On Cis The checklist is used to fine tune WLC configuration to match the best practices as suggested by Cisco. The checklist compares the local con best practices. Use of best practices is highly recommended for a WLAN deployment involving WLCs.

Deployment Platform Choices: Campus Wired and Wireless LAN

An organization chooses from the spectrum of switching and wireless platforms based on the needs of capacity, capabilities, and compliance. network size.

Small-site campus design

The small-site campus design is a single 24 or 48-port access switch or single access switch stack. The demands in the access layer for wired minimize cost with minimal numbers of components and features offered, though advanced and mission critical options are available choices

Campus wired access and wireless access

In the small-site campus design, you make choices for the wired access with a bias towards size and flexibility in order to accommodate the space economical preference are shown.

**Table 6.** Small campus suggested deployment platforms (single-tier network)

| | Enterprise Class—base foundation network capabilities | Advanced—foundation plus additional network capabilities | Mission Critical—Best in cl capabilities |
|---|---|---|---|
| **Access switches** | Cisco Catalyst 9200 and 9200-L Series | Cisco Catalyst 9300 and 9300-L Series | Cisco Catalyst 9404R Switch |
| **WLAN controller** | Cisco Catalyst 9800 Embedded on Catalyst 9100 Series Access Points (EWC) or Cisco Catalyst 9800-CL | Cisco Catalyst 9800-L HA SSO pair or N+1 or Cisco Catalyst 9800-CL | Cisco Catalyst 9800-L HA S |
| **APs** | Cisco Catalyst 9115AX or 9117AX Series | Cisco Catalyst 9120AX Series | Cisco Catalyst 9130AX Series |
| **Key capabilities—wired** | Gigabit Ethernet access | Gigabit Ethernet services, MACsec, TrustSec NetFlow, PoE+ | Gigabit Ethernet services, M UPOE |

| | | | |
|---|---|---|---|
| **Key capabilities—wireless** | Wi-Fi 6 (802.11ax), OFDMA, Uplink/Downlink MU-MIMO, BSS Coloring, Target Wake Time (TWT), Apple Features | Wi-Fi 6 (802.11ax), Cisco RF ASIC, Uplink/Downlink OFDMA, MU-MIMO, BSS Coloring, Target Wake Time (TWT), Intelligent Capture, Container support for applications, Apple Features | Wi-Fi 6 (802.11ax) certi support for applications, |

| | | | |
|---|---|---|---|
| | mGig, Cisco CleanAir, Three radios: 2.4 GHz (4x4), 5 GHz (4x4)or(8x8), and BLE | mGig, Cisco CleanAir, HDX, FRA, Four radios: 2.4 GHz (4x4), 5 GHz (4x4), Cisco RF ASIC, and BLE/IoT hardware capable | mGig, Cisco CleanAir, HDX BLE/IoT hardware capable |
| Medium-density campus design | | | |
| The medium-density campus design adds a single distribution layer to the access layer, which can be standalone or used as a collapsed core conne demands in the access layer for wired ports and WLAN devices typically number in the hundreds versus the thousands for a large design, with re offered and standard network capabilities. | | | |
| Campus wired distribution, wired access, and wireless | | | |
| You make choices for the wired distribution and access with a bias towards size and flexibility in order to accommodate the space and power requ not as strong of a requirement, options with a more economical and common sparing preference are shown. | | | |
| The medium-density designs are equivalent to the small-site campus design with the addition of a distribution layer. | | | |

**Table 7.** Medium campus suggested deployment platforms (two-tier network)

| | | | | |
|---|---|---|---|---|
| | | Enterprise Class—base foundation network capabilities | Advanced—foundation plus additional network capabilities | Mission Critical—Best i capabilities |
| | **Distribution/aggregation switches** | Cisco Catalyst 9400 Series | Cisco Catalyst 9500 Series | Cisco Catalyst 9600 Series |
| | **Access switches** | Cisco Catalyst 9200 and 9200-L Series | Cisco Catalyst 9300 and 9300-L Series | Cisco Catalyst 9400 Series |
| | **WLAN controller** | Cisco Catalyst 9800-40 or Cisco Catalyst 9800-CL | Cisco Catalyst 9800-40 HA SSO pair or N+1 | Cisco Catalyst 9800-40 pair |
| | **APs** | Cisco Catalyst 9115AX or 9117AX Series | Cisco Catalyst 9120AX Series | Cisco Catalyst 9130AX Series |
| | **Key capabilities—wired** | 1/10 Gigabit Ethernet services, MACsec, TrustSec NetFlow | 1/10 Gigabit Ethernet services, MACsec, TrustSec NetFlow, UPOE | 1/10/40 Gigabit Etherne NetFlow, UPOE |

| | | | | |
|---|---|---|---|---|
| | **Key capabilities—wireless** | Wi-Fi 6 (802.11ax), OFDMA, Uplink/Downlink MU-MIMO, BSS Coloring, Target Wake Time (TWT), Apple Features | Wi-Fi 6 (802.11ax), Cisco RF ASIC, Uplink/Downlink OFDMA, MU-MIMO, BSS Coloring, Target Wake Time (TWT), Intelligent Capture,  Container support for applications, Apple Features | Wi-Fi 6 (802.11ax) certified support for applications, Ap |

| | | | |
|---|---|---|---|
| | mGig, Cisco CleanAir, Three radios: 2.4 GHz (4x4), 5 GHz (4x4)or(8x8), and BLE | mGig, Cisco CleanAir, HDX, FRA, Four radios: 2.4 GHz (4x4), 5 GHz (4x4), Cisco RF ASIC, and BLE/IoT hardware capable | mGig, Cisco CleanAir, I BLE/IoT hardware capa |

| |
|---|
| High-density large campus design |
| The high-density large campus design has multiple distribution layers connected to a core layer and dense demands in the access layer for wir critical business continuity or advanced capabilities. |
| Campus core |
| If there are three or more interconnected distributions or requirements for connectivity at a common location, you use a Layer 3 LAN core in design. The flagship platforms for these options: |
| • Cisco Catalyst 9600 Series—The lead high-density modular platform choice. |
| • Cisco Catalyst 9500 Series—The lead lower-density fixed platform choice. |
| Campus wired distribution, wired access, and wireless |
| In the high-density large campus, you make choices for the wired distribution and access based on the most highly available platforms for the software feature capabilities. |
| In the high density large campus design, centralized wireless is the preferred option, using APs with 802.11ac Wave 2 and CleanAir |

capabilities.

**Table 8.** High-density large campus suggested deployment platforms (three-tier network)

| | Enterprise Class—base foundation network capabilities | Advanced—foundation plus additional network capabilities | Mission Critical—Best in cl capabilities |
|---|---|---|---|
| **Core switches** | Cisco Catalyst 9500 Series | Cisco Catalyst 9600 Series | Cisco Catalyst 9600 Series |
| **Distribution/aggregation switches** | Cisco Catalyst 9400 Series | Cisco Catalyst 9500 Series | Cisco Catalyst 9600 Series |
| **Access switches** | Cisco Catalyst 9200 and 9200-L Series | Cisco Catalyst 9300 and 9300-L Series | Cisco Catalyst 9400 Series |
| **WLAN controller** | Cisco Catalyst 9800-80 | Cisco Catalyst 9800-80 HA SSO pair | Cisco Catalyst 9800-80 HA pair |
| **APs** | Cisco Catalyst 9115AX or 9117AX Series | Cisco Catalyst 9120AX Series | Cisco Catalyst 9130AX Series |

| | | | | |
|---|---|---|---|---|
| | **Key capabilities—wired** | 1 Gigabit Ethernet access, PoE+ | 1/10/40 Gigabit Ethernet services, MACsec, TrustSec MPLS, NetFlow, UPOE | Highest availability 1/10 NetFlow, UPOE |

| | | | | |
|---|---|---|---|---|
| | **Key capabilities—wireless** | Wi-Fi 6 (802.11ax), OFDMA, Uplink/Downlink MU-MIMO, BSS Coloring, Target Wake Time (TWT), Apple Features | Wi-Fi 6 (802.11ax), Cisco RF ASIC, Uplink/Downlink OFDMA, MU-MIMO, BSS Coloring, Target Wake Time (TWT), Intelligent Capture,  Container support for applications, Apple Features | Wi-Fi 6 (802.11ax) certified support for applications, Ap |

| | | | |
|---|---|---|---|
| | mGig, Cisco CleanAir, Three radios: 2.4 GHz (4x4), 5 GHz (4x4)or(8x8), and BLE | mGig, Cisco CleanAir, HDX, FRA, Four radios: 2.4 GHz (4x4), 5 GHz (4x4), Cisco RF ASIC, and BLE/IoT hardware capable | mGig, Cisco CleanAir, I BLE/IoT hardware capa |

Operate: Common Components in Campus Designs

Device management using Cisco ISE

Without a centralized access and identity policy enforcement point, it's difficult to ensure the reliability of a network as the number of networ administrators increases.

Cisco ISE operates as a centralized AAA server that combines user authentication, user and administrator access control, and policy control i and conditions in addition to a user's identity.

The capabilities of Cisco ISE coupled with a AAA configuration on the network devices reduce the administrative issues that surround having or revoke access for a user on any network device.

Rule-based mapping of users to identity groups can be based on information available in an external directory or an identity store such as Mic or role in the network. The combination of identity and device groups allows you to easily create authorization rules that define which networ

These same authorization rules allow for privilege-level authorization, which can be used to give limited access to the commands on a device monitoring commands.

Cisco DNA Center

As networks and the number of services they support continue to evolve, the responsibilities of network administrators to maintain and improve t network administrators.

Cisco DNA Center is a controller for planning, preparation, installation, and integration. Cisco SD-Access is one of the many software applicatio on DNA Center.

Cisco DNA Center centrally manages major workflow areas, including:

- **Design**—Configures device global settings, network site profiles for physical device inventory, DNS, DHCP, IP addressing, software image m user access.
- **Policy**—Defines business intent for provisioning into the network, including creation of virtual networks, assignment of endpoints to virtual ne definition for groups.
- **Provision**—Provisions devices for management and creates fabric domains, control plane nodes, border nodes, edge nodes, fabric wireless, loc connectivity.
- **Assurance**—Enables health scores dashboard, client/device 360° views, node, client, and path traces.

Cisco DNA Center supports integration using APIs. For example, Infoblox IP address management and policy enforcement integration with ISE integration, and innovation.

- All controller functionality is exposed through northbound REST APIs.
- Organizations and ecosystem partners can easily build new applications.
- All northbound REST API requests are governed by the controller RBAC mechanism.

Cisco DNA Center is key to enabling automation of device deployments into the network providing the speed and consistency required for operat maintaining their networks.

Cisco Prime Infrastructure

Cisco Prime Infrastructure is a sophisticated network management tool that can help support the end-to-end management of network technologies Cisco Prime Infrastructure provides an intuitive, web-based GUI that can be accessed from anywhere from within the network and gives you a fu

With a campus network and the services that it can support, Cisco Prime Infrastructure can play a critical role in day-to-day network operations.

Device Work Center

Cisco Prime Infrastructure includes the Device Work Center. Some of the features found in the Device Work Center are:

- **Discovery**—Builds and maintains an up-to-date inventory of managed devices, including software image information and device configuration
- **Configuration Archives**—Maintains an active archive of multiple iterations of configuration files for every managed device.

| |
|---|
| • **Software Image Management**—Enables a network administrator to import software images from Cisco.com, managed devices, URLs, or group of devices. |
| Configuration Templates and Tasks |
| Using the Configuration Tasks feature to apply configuration templates to many devices, administrators can save many hours of work. Cisco configuration needs, Cisco Prime Infrastructure enables you to define your own templates. |
| Alarms, Events, and Syslog Messages |
| Cisco Prime Infrastructure provides the Alarms and Events feature, which is a unified display with detailed forensics. The feature provides ac Assistance Center. |
| Reporting |
| Cisco Prime Infrastructure provides you a single launch point for all reports that you can configure, schedule, and view. The Report Launch P customize as needed. |
| Cisco CleanAir support |
| Cisco Prime Infrastructure supports the management of CleanAir enabled wireless APs, enabling administrators to see interference events. |
| Network Analysis Module support |
| For increased visibility into your network, Cisco Prime Infrastructure supports management and reporting for Cisco Network Analysis Module products. |
| Cisco Prime Infrastructure and Cisco DNA Center choices for WLAN deployments |
| The following are recommendations when deciding to use Cisco Prime Infrastructure instead of, or in addition to, deploying Cisco DNA Cent wireless deployment. |
| Organizations with new WLAN deployments |
| If you are an organization with a new wireless deployment, consider using Cisco DNA Center for both automation (management) and assuran of Cisco DNA Center can simplify and standardize the deployment of wireless controller software images across your network. For Cisco SD within Cisco DNA Center for more advanced configuration. |
| Organizations refreshing wireless networks or deploying new wireless sites |
| If you are an organization refreshing your WLAN with Cisco Catalyst 9800 Series WLCs and Cisco Catalyst 9100 Series APs to take advanta efficiencies of 802.11ax (Wi-Fi 6): |
| • For new sites, consider using Cisco DNA Center for both automation (management) and assurance. |
| • For existing sites, consider Prime – Cisco DNA Center co-existence for network management. Use Cisco Prime Infrastructure for reportin |

configurations, and functionality currently not supported within Cisco DNA Center. Cisco DNA Assurance provides advanced troubleshooting ca
Spaces integration for location. Only one system – Cisco Prime Infrastructure or Cisco DNA Center – should be allowed to make changes to the

**Note:** Cisco Prime Infrastructure release 3.5.1 update 1 and higher includes a Prime to Cisco DNA Center co-existence tool. The tool is design
configuration from Cisco Prime Infrastructure to Cisco DNA Center.

Organizations with existing WLAN deployments

For organizations with existing WLAN in production deployments, consider Cisco Prime Infrastructure coexistence with Cisco DNA Center for r
assurance. As Cisco DNA Center functionality develops to replace required functionality in Cisco Prime Infrastructure, or as the existing devices

Campus quality of service (QoS)

Because real-time communication traffic is very sensitive to delay and drop, the network must ensure that this type of traffic is handled with prior
answers this need.

The primary role of QoS in rich-media campus networks is to manage packet loss, where high-bandwidth links with instantaneous congestion on
treatment of traffic for a predictable user experience across the entire enterprise network.

QoS allows an organization to define different traffic types and to create more deterministic handling for real-time traffic. QoS is especially usefu
when links are oversubscribed by aggregating traffic from several devices, and also when traffic on a link to a device has come from upstream lin

Within the campus wired LAN, Cisco keeps the QoS profiles as simple as possible while ensuring support for applications that need special deliv
the entire network.

The primary goals of implementing QoS within the network are:

- Expedited delivery service of communications for supported, real-time applications.
- Business continuance for business-critical applications.
- Fairness among all other applications when congestion occurs.
- Deprioritized background applications and non-business entertainment-oriented applications so that these do not delay interactive or business-c
applications.
- A trusted edge around the network to guarantee that users cannot inject their own arbitrary priority values and to allow the organization to trust
network.

To accomplish these goals, the design implements QoS across the network as follows:

- Establish a limited number of traffic classes (that is, four to twelve classes) within the network that need special handling (for example, real-tir
default classes).
- Classify applications into the traffic classes.
- Apply special handling to the traffic classes to achieve intended network behavior.

To deploy QoS, use the Application Policy feature in Cisco DNA Center to configure quality of service on the discovered switching devices in yo
configurations and deploys the configurations to the devices. Additionally, use Cisco DNA Assurance to gain visibility into the applications and a

| |
|---|
| For additional information, visit cisco.com and search for Application Policy. |
| |
| |
| Appendix: Glossary |
| **AAA** authentication, authorization, and accounting |
| **ACL** access control list |
| **ACS** Cisco Access Control Server |
| **AP** access point |
| **AQ** air quality |
| **AUP** acceptable use policy |
| **AVC** Cisco application visibility and control |
| **BGP** border gateway protocol |
| **BYOD** bring your own device |
| **CAPWAP** control and provisioning of wireless access points protocol |
| **DCA** dynamic channel assignment |
| **DFS** dynamic frequency selection |
| **DMZ** demilitarized zone |
| **DNA** Cisco Digital Network Architecture |
| **DPI** deep packet inspection |
| **EAP** extensible authentication protocol |
| **EUA** end-user agreement |
| **EVPN** Ethernet virtual private network |
| **FHRP** first-hop redundancy protocol |
| **FRA** flexible radio assignment |
| **G2** second generation |
| **GLBP** gateway load-balancing protocol |

| |
|---|
| **HA** high availability |
| **HA SSO** high availability stateful switchover |
| **HSRP** hot standby routing protocol |
| **ISE** Cisco Identity Services Engine |
| **ISM** industrial, scientific, and medical band |
| **LACP** link aggregation control protocol |
| **LAG** link aggregation |
| **LAN** local area network |
| **mDNS** multicast domain name services |
| **MFP** management frame protection |
| **MIMO** multiple input, multiple output design |
| **NBAR2** Next Generation Network-Based Application Recognition |
| **PAgP** port aggregation protocol |
| **PHY** physical layer |
| **PI** Cisco Prime Infrastructure |
| **PMF** protected management frames |
| **PSK** pre-shared key |
| **QAM** quadrature amplitude modulation |
| **QoS** quality of service |
| **RBAC** role-based access control |
| **RF** radio frequency |
| **RRM** radio resource management |
| **RSSI** received signal strength indicator |
| **Cisco SD-Access** Cisco Software-Defined Access |
| **SSID** service set identifier |
| **SSO** stateful switchover |
| **STP** spanning tree protocol |

| |
|---|
| **SVL** Cisco StackWise Virtual Link |
| **TPC** transmit power control |
| **TTL** time-to-live |
| **TxBF** standards-based transmit beamforming |
| **UPOE** Cisco Universal Power Over Ethernet |
| **UPOE+** Cisco Universal Power Over Ethernet Plus |
| **VLAN** virtual local area network |
| **VRRP** virtual router redundancy protocol |
| **SV** StackWise Virtual |
| **vWLC** virtual wireless local area network controller |
| **VXLAN** virtual extensible local area network |
| **WAAS** wide area application services |
| **WAN** wide area network |
| **WIDS** wireless intrusion detection system |
| **wIPS** wireless intrusion prevention system |
| **WLAN** wireless local area network |
| **WLC** wireless local area network controller |
| **WSM** Wireless Security Module |
| |
| |
| |
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| |
| |

e, understanding the Salesforce architecture makes working with the platform a whole lot easier.

# diagram

Applies To

Use the **Electrical Engineering** drawing type in Visio Professional or Visio Plan 2 to create electrical and electronic schematic diagrams.

1. On the **File** tab, select **New**, and then search for **Engineering** templates.
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- **Circuits and Logic**
- **Fluid Power**
- **Industrial Control Systems**
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**Drawing**

- **Piping and Instrumentation Design**
- **Plumbing and Piping Plan**
- **Process Flow Diagram**
- **Systems**
- **TQM diagram**
- **Work Flow Diagram**

3. Choose **Metric Units** or **US Units**, and then select **Create**.

The template opens an unscaled drawing page in portrait orientation
. You can change these settings at any time.

## Block diagram of a smart energy metering circuit

## architecture

Source publication

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**ARCHITECTURE AND APPLICATION DESIGN**

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